When Youth Scientists Disrupt the Riptide of Environmental Precarity:
Lessons on Authoring Ecological Hope, Narrating Fieldwork & Designing for Ecojustice

Kelsie Fowler

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Reading Committee:
Jessica Thompson, Chair
Mark Windschitl
Filiberto Barajas-López
José Antonio Lucero

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Abstract

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Chair of the Supervisory Committee:
Dr. Jessica Thompson
College of Education

This dissertation features a set of three sub-studies situated within a larger Critical Participatory Ethnography investigating how participatory science unfolds between youth and scientists to address issues of marine plastic pollution in a remote town on the Baja Peninsula of Mexico. Collectively the papers provide insights into how to navigate the slippery, but necessary, terrain of teaching for environmental justice and worlds beyond the Anthropocene. Analysis of youth and community member interviews, photographs, audio recordings, and field logs revealed important findings regarding how youth engaged and responded to learning about marine degradation and considerations of this type of science education. In three cases of the focal girl participants, ecogrief and ecological hope are found to work in tandem to author new worlds that extend, repair, or reimagine parts of their identities that have been, or are perceived to be at risk of being, severed. The findings reveal that the girls pulled on important and varied supports to author ecological hope. Additionally, iterative reflexive coding and retrospective analysis of data through a critical multilogics lens shaped by ontologies that disrupt "*master narratives*" also exposed methodological problems or shortcomings of the scientific work undertaken by the youth. These "*conundrums*" and "*neglected narratives*" necessitate pauses in learning and a new science practice I call "*socio-ecological minding*". To provide a more detailed vision of how

socio-ecological minding occurs, in the findings several *"conundrums"* and *"neglected narratives"* are shared and then critically narrated through socio-ecological minding. This process illuminates several important points of consideration within the youths' work itself, including: the ongoing revision of science, the need to disrupt the temporality of science, our best intentions as multiplying horcrux, extending consent to nature and the stickiness of doing science in community. To extend these findings toward practicing science educators, I conclude the dissertation by presenting the Critical Community Science tool I had designed to design, evaluate, and reflect upon the participatory science work unfolding with youth through the Plastics Project. Building upon experiences with guest science educators learning to apply the tool to their own work, I introduce different ways the tool was taken up and end by identifying areas of support for science educators wanting to attend to environmental justice.

TABLE OF CONTENTS

DEDICATION

This dissertation is dedicated to my family and specifically my children, Nico and Saya. Nothing is more important than you, and for you I fight and hope for a better future. My dream is that it is always easy for you to author worlds of hope beyond what you face. May you find rest from seas of grief, and that all the oceans will walk beside you in protective wonder and love.

ACKNOWLEDGEMENTS

First and foremost, I want to acknowledge that I lived, worked, and studied on the ceded and unceded lands and waterways of the Coast Salish and Cochimí peoples. I acknowledge that these Indigenous peoples were and are the original stewards of these places and I am therefore challenged to name their complex pasts and present traumas, and triumphs, to be a better ally through environmental justice education.

I am grateful for the Aventureros who taught me to see plastics—even if I now see them in dreams and nightmares. I appreciate these youths' kindness, questions, vulnerability, and radical scientific work. I was gifted with so many laughs, stories, discoveries, drawings, and pieces of these youth, which is an honor and I promise to hold these carefully. Because of my time with these brilliant and visionary individuals, I now have hope in a life that is not plastic-free but one that can heal from plastics. With hard work, joy, and care I believe they will each make a profound imprint on this world. ¡Muchas gracias y yo no puedo esperar a estar contigo!

My deepest thanks to my VSI colleagues who trusted me to come alongside them and embraced the radical and complicated ideas I kept throwing out there. Romina, Meghann, Brent, T'Noya, Lalo, and Alex your truth nuggets, curiosity of things above and below the water, care for the Aventureros, care for my family, and critical faith in this work held me accountable and continues to challenge me to do better. I can't wait to see you soon!

I am grateful for my committee, including Dr. Jessica Thompson, Dr. Mark Windschitl, Dr. Filiberto Barajas-López, and Dr. Tony Lucero for coming on this journey with me and supporting this work. Special thanks to Mark, who I owe infinite coffees to for his endless support, patient and wise scholarly writing advice, general championing, and mentorship—I feel constantly lucky to have stumbled under your wing. And to Tony who gives the best book recommendations, asks hard questions, and always challenges me to do better.

This list gets long but necessarily so. (Note: I started this a few months ago when this journey began to feel impossible. Writing it became a reminder of why I am here and that I need to finish for all those who support/ed me along the way.)

To my husband, confidant, and sometimes editor Austin. He was the first to witness my obsession with the brilliance of youth and more-than-human species, environmental justice, plastics, and all the other unnamed pieces to this puzzle. He endured long desert drives with toddlers, unfiltered grumbles about plastic consumption, and withstood the emotional rollercoaster that comes with doing a PhD focused on realizing educational justice in a world on fire. Auto, thank you for taking my unpolished, tired words and going on this journey with me. Let's celebrate.

To my mom, Kelly, who may be the best teacher I know and tried out early forms of socio-ecological minding with her classroom bird feeder. Teaching is in my DNA because of you, and I hope that when I am on the brink of retiring, I still care as much about doing it well as you do. Thank you for the phone calls, watching Nico y Saya, teaching me to drywall, and having hope when I needed it. You are a good Abuela.

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To the mythical creature Amaye-Ben, who brought us food, a dishwasher(!), and encouragement at all the right junctures. Thank you for believing in me, despite your front-row view of how maddening this all was.

To my Grandpa who I don't see eye-to-eye with always ☺, but who embodies what family means in ways everyone needs and deserves to learn from—I love you very much and a part of me will always think of you and Grandma as home.

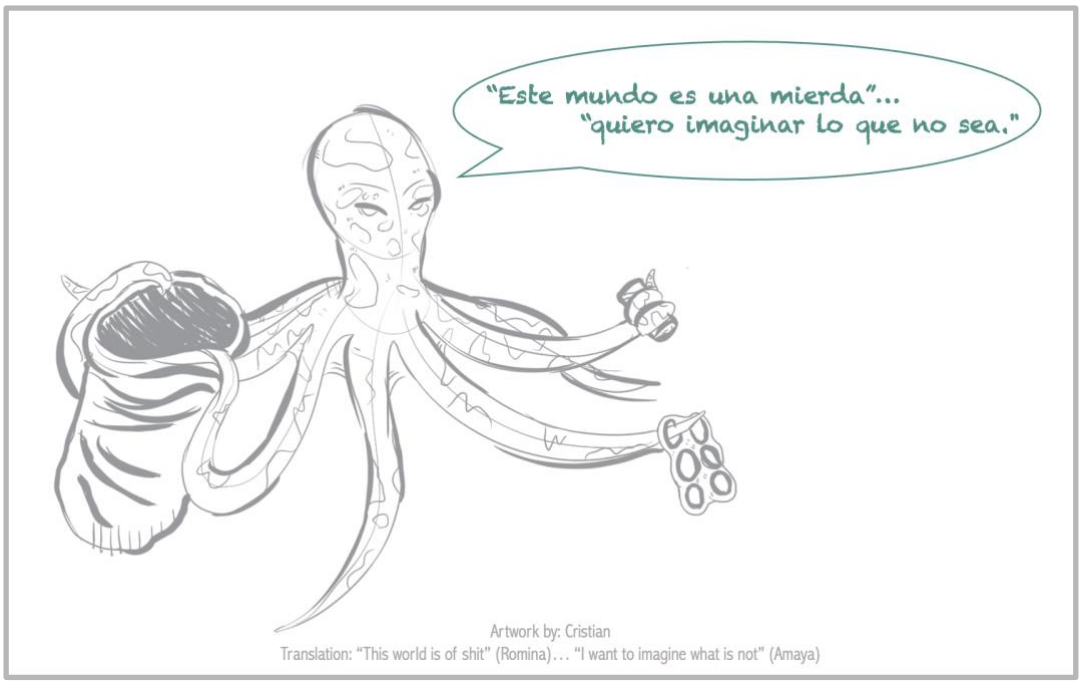
Many thanks to the animal families in my life… the Tigers and the Krows. You both are, and have been, constant sources of joy, intellect, family, and friendship.

And to my kind and brilliant friends. Anastasia thanks for being a pain-in-the-ass thought partner and cheerleader during the darkest times. You taught me to bet on myself when I needed this the most. Cristina, thank you for sharing your parenting savviness, food, stories, listening ear, and babysitter—está la hora para "sobre la mesa". To Saraswati, for always being a light in the darkness and seeing me. To Caroline, for cookies that then became mojitos two years later,

job ideas, and steady encouragement. To Olga, Sarah, and Chris for your loving words, references, and cat GIFs.

This list reads like an incredibly powerful and loving gang—thank you all for having my back!

INTRODUCTION



This dissertation is about the brilliance of youth as scientists and change agents of this world. It is also about recognizing the Earth, and oceans, as a powerful source of life and well-being and responding through science education to the precarious and threatened state of our planet. The ongoing environmental catastrophes facing the children sitting in our classrooms necessitates that science learning attends to youth's futurity by teaching about, and for, the disruption of these matters of socio-ecological concern and destruction. Many scholars urge for learning that moves youth toward deeper forms of gratitude, responsibility, and socio-ecological care. However, little is understood about how to support students in developing deep care about this world, and especially marine settings. Furthermore, there exists a call for more research around transitioning people out of apathy and into taking action for environmental justice.

Using these understandings as a point of departure, my goal is to humbly contribute to what is understood about teaching science amid the rising tides of ecological loss and ecogrief. Having accurate and deep knowledge of the problems facing Earth and its resilience (Whyte, 2018) is vital, but my work aims to shed light on the role self and group reflexivity can play in improving how science unfolds and for whom. To do this I present examples of youth as scientists and environmental justice leaders in the face of the global ecological crisis created by

marine pollution. Across the series of three papers, each presented as a separate section of this dissertation, these examples coalesce to create a sharper image of how formal and informal science educators can better support students through these learnings. Among the many lessons are ideas about authoring future worlds as first steps to living beyond the Anthropocene, critically narrating and then modifying inquiries in a new practice I call "socio-ecological minding", and what should be considered when enacting environmental justice projects/units.

Like many others, I do not envy the arduous task set before educators and believe that given every resource at our disposal we must unite around these issues and imagine together learning that realizes profound ecological care and environmental justice. Therefore, this dissertation is my response to the question "how can we best use our research to stem the tide of ruination?" (Gan, Tsing, Swanson & Bubandt, 2017, p. G1). In sharing lessons learned throughout this study, I hope to come alongside science educators as they respond to environmental degradation and take on teaching about and for environmental justice and futures beyond the Anthropocene. To "stay with this [good] trouble" (Haraway, 2016), I ground this work in the following research questions:

1. How do youth emotionally respond to learning about issues of environmental/marine destruction and what sources of ecological hope and motivation do they draw on as they engage in environmental justice projects?
2. How can a practice of reflexivity apply to field inquiries as an approach to growing students' responsibility, relationality, and care toward their humans and more-than-human communities. What opportunities exist for critically narrating inquiries in ways that are expansive but also foster better caring for the world and beings in it?
3. What role can the Critical Community Science tool play in designing, sustaining, and evaluating participatory science research aimed at realizing environmental justice? How are ideas, perspectives, knowledges, and solutions attended to by using the tool?

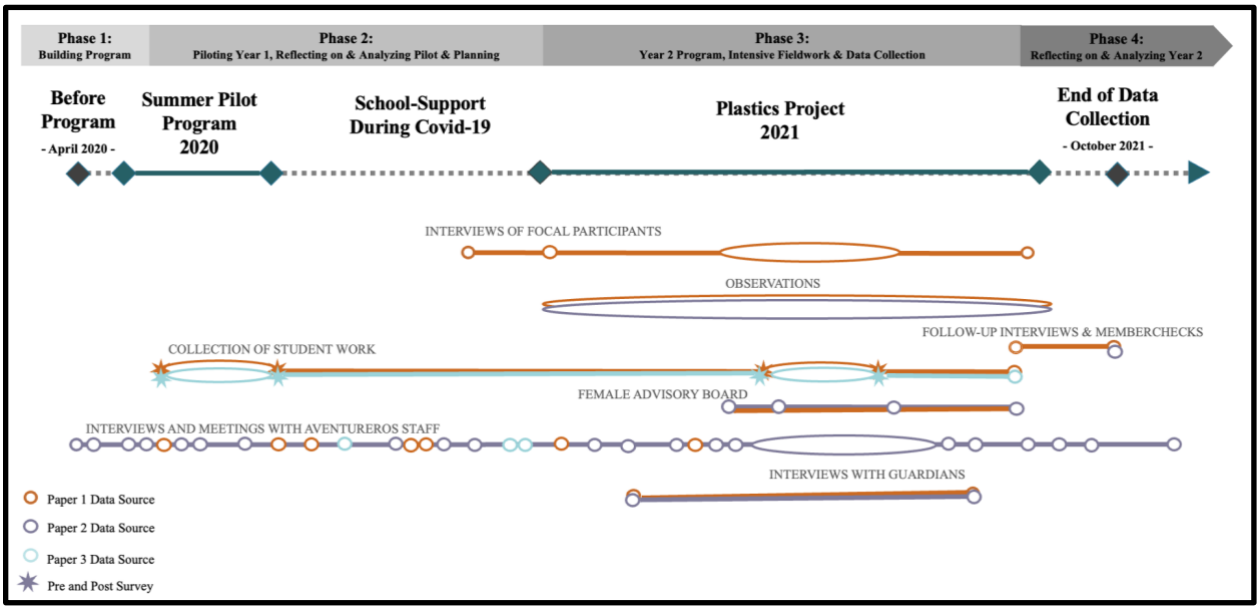
Design of Study

The research featured in this dissertation originated from a multi-year critical participatory ethnography (Anderson, 1989; Madison, 2020) and partnership with the Vermilion Sea Institute (VSI) in Bahía de los Ángeles, México. In June of 2020, I was on a small team that helped VSI formalize their efforts to invite Mexican youth from the local community to learn about the local ecosystem and participate in long-term science research as scientists. In contrast to most projects,

we explicitly designed the environmental education program to facilitate socio-ecological care (Haraway, 2016; Puig de la Bellacasa, 2017; Learning in Places, 2020) and explore issues related to consequential concern (Shume, 2015; Bang and Medin, 2010). As shown in Figure 1, most of the data featured here was collected during the late spring and summer of 2021 when the youth scientists were deeply engaged in the "Plastics Project"—a youth participatory science project to study and address marine plastic pollution issues in their local waters.

Figure 1.

Timeline Overview of Dissertation Research and Partnership



As this is a critical participatory ethnography (Anderson, 1989; Madison, 2020), data was collected under varying conditions, at different locations, informally and formally, over many months, and as I engaged not as an outsider looking in but as a co-facilitator of the program. Iterative coding, participant portraits, and thematic analysis techniques were used across this study to present descriptive cases from the data—which included a series of ethnographic interviews, audio recordings of lessons and activities, photographs, student and field artifacts, field logs, and my personal research journal.

While quite different, all three of the papers are grounded in the field of environmental justice which aims to "to evaluate the holistic connections between cultural and natural systems, environmentalism, sustainability and youth activism" (Mueller & Tippins, 2015). Due to this,

similar frameworks, authors, approaches to teaching for environmental justice, and descriptions of the context or data collection are used across the papers. The three stand-alone papers include:

Section 1. Lessons from the girl boat: Treading in a plastic sea of grief and authoring ecological hope

Understanding how youth respond to learning about environmental exploitation, degradation and loss is essential work given the world we live in. Furthermore, many teachers are at a loss for how to support students' varied ecoemotions as their environmental consciousness grows (Verlie et al., 2021; Phikala, 2020)—which often causes many educators to avoid teaching about the precarious state of our world. In this multi-year critical participatory ethnography, I present three cases of Mexican youth living in a small fishing community studying and trying to combat marine plastic pollution in local waters. Their responses to learning about marine destruction (1) disrupt the dichotomy often assigned to ecogrief and ecological hope, (2) urge scientists and science educators to abandon emotional stoicism, (3) illustrate how youth author futures beyond environmental harm and (4) challenge who teachers are and who they should be.

Together their stories challenge us to understand that youth aren't simply drowning in grief or floating with hope—they live in a Pelagic Zone with all the ways of being and feeling existing at once. Furthermore, their stories reveal what it looks like for youth to process ecogrief and attend to the parts of themselves that have been lost, or are anticipated to be lost, by authoring a hopeful and flourishing world, ocean, and personal future. Drawing upon the concept of "active hope" (Verlie, Clark, Jarrett & Supriyono, 2021), this presentation ends by considering ecological hope as an action of identity authoring (Holland et al., 1998; Johnson et al., 2010) and "worlding" against forms of environmental degradation and eco-apocalyptic or post-apocalyptic narratives (Haraway, 2016; Mitchell & Chaudhury, 2020; Whyte, 2018). Their cases reveal that worlding beyond the Anthropocene is a disciplined practice that is shaped by critiquing this world, centering our intergenerational and multispecies relatives, developing new skills and knowledge, and knowing more-than-humans as teacher. Moving forward we must remember that students are not powerless victims of marine and other forms of environmental violence, they are authors of tomorrow.

Section 2. Socio-ecological Minding: Examining methodological conundrums & neglected narratives of inquiry with youth

In this paper I extend the suggestions of Gloria Snively and Wanosts'a7 Lorna Williams, who argue that the *process* of youth inquiry itself should undergo rigorous evaluation for effects of personal or group actions (Snively & Williams, 2016). To do this I build upon the strengths and critiques of socio-ecological care (Learning in Places, 2020; Haraway, 2016; Puig de la Bellacasa, 2017) and argue for a new science practice called "*socio-ecological minding*". Socio-ecological minding prompts youth and researchers to pause and analyze problems or shortcomings of their scientific work through a critical lens informed by ontologies that disrupt harmful narratives, practices, and paradigms of dominant science endeavors (Haraway, 2016; Bang, Brown, Calabrese Barton, Rosebery & Warren, 2017; Whyte, Brewer & Johnson, 2015). By designing intentionally for "Socio-ecological Minding", youth can learn to push against "master narratives" that reify socio-ecological issues.

These suggestions stem from the multi-year Plastics' Project and emerge from methods that were designed retrospectively to identify and reflect upon methodological shortcomings. Through an iterative analysis and coding process it became clear that some methodological failures were troubled and discussed among the group, these I call *"conundrums".* While other shortcomings remained *"neglected narratives"*, never storied or discussed by the team. The findings weave together student dialogue, field photos, personal journal entries and interview data to story one major conundrum and two neglected narratives that should have been explicitly troubled by our research group during the project. While it is impossible to account and care for/about/with everything, pausing frequently to question and narrate how learning or research is unfolding is essential in developing powerful alternatives to socio-ecological problems.

Section 3. Designing, sustaining, and evaluating environmental justice projects: The Critical Community Science Tools

Although issues of environmental injustice are rampant in today's world, engaging youth in science learning about these topics is overwhelming to many educators and remains a nascent practice. In this paper, I present the Critical Community Science (CCS) tool which is designed to support educators in using citizen science or other place-, project- or problem-based learning experiences to guide youth through studying phenomena grounded in environmental justice. As

described in the paper, the five dimensions and accompanying prompts of the CCS tool can be used iteratively and in a variety of ways to design, evaluate, and modify environmental justice research/projects. Organized chronologically, this study begins with the context of the marine Plastics' Project in which the tool was originally designed to support, a description of the tool itself, and how it was taken up in this project.

The paper then transitions to summarizing how science educators responded to the tool and used it to evaluate, modify, or design science learning units/activities/programs attending to environmental justice phenomenon. Working alongside educators with the CCS tool illuminated several important constructs for realizing environmental justice that many of the educators were unfamiliar with. The paper concludes by exploring these areas and suggesting ways the tool can support educator learning, so science learning can help realize environmental justice.

SECTION 1

Lessons from the girl boat:
Treading in a plastic sea of grief and authoring ecological hope

Toward the end of the summer Idra was burning an afternoon bouncing between a dance off with her cousins and rapping about our project. "And I like how the animals survive, the turtles would not be forgotten, and the wolves would not die. The dolphins would not entangle and the microplastics would not exist…with care to our bay, we can manage not to extinguish them—as they were with the vaquita…I'll also talk to you about Aventureros–a place full of dreams. This is how my dream of oceanology came, came with what we are grasping, we cannot pollute…" Once her cousins left, I asked Idra if she wanted to continue monitoring plastics this coming year with the Aventureros. She flashed an indignant face and then powerfully snarked "Listen. This is a really big problem and I want to help my bay but <u>look at me</u> (signals down her body, flips hair and pouts her lips in one fluid gesture), I am <u>not</u> a trash person! (Eyebrows raise in my direction)—I want to learn about whale sharks and dolphins and those things."

Disrupting the Anthropocene and teaching for the future of our oceans and other marine environments is not easy. As teachers take up this challenging work, youth can enact consequential care (Puig de la Bellacasa, 2017) and author unique forms of ecological hope. The epigraph, featuring Idra, represents the profound puzzlement of how youth care for these places and the more-than-human beings inhabiting them but how they can also quickly shift to ego-centric concerns or seemingly disengage from the topic (Ballard, Dixon & Harris, 2016; Schusler, Krasney, & Decker, 2017). Therefore, understanding different ways youth relate to marine (and terrestrial) environments and how their growing critical consciousness impacts their participation in environmental science learning is essential work of our time (Visbeck, 2018; Martin et al., 2015; Learning in Places, 2021).

While many science educators insist there is no way forward but to address the environmental precarities of this world (ie., pollution, climate change, species extinctions), there is growing concern that learning about the state of our natural world may induce, or exacerbate, "ecogrief" or "ecoanxiety" among students (Grauer, 2020; Schusler, Krasney, & Decker, 2017). Ecogrief is defined as "the grief and sadness felt in response to the loss of beloved places,

ecosystems, and species", whereas ecoanxiety is "the anxiety related to current and predicted environmental damage or loss, particularly from the climate crisis" (Ojala et al., 2021, p. 37). Although closely related, I focus on ecogrief throughout this paper because it better represents palpable losses already impacting the youth featured in this study.

Supposedly after youth are introduced to environmental degradation outside of their everyday reality, they are inundated with unnecessary loss and planetary problems beyond their influence, affectively "stealing their childhoods" (Grauer, 2020). While scholars are divided about the actual impact this learning can have on youth, most acknowledge that even the best-intentioned programs can result in apathy, immobilizing anxiety, depression, or anger, which can disengage students from the problem or nature altogether (Ballard, Dixon & Harris, 2016; Grauer, 2020; Schusler, Krasney, & Decker, 2017). Complicating the matter, youth will share their grief and worries about environmental degradation with others (Ballard et al., 2016) but often unprompted and in unexpected forms of resistant self-determination (Davis, Vossoughi & Smith, 2020). For example, while Idra carried hope and care for the ocean, her righteous anger about marine plastic pollution and its impacts on animals and her own life led to her defensive demand to be acknowledged as someone outside of ecological destruction.

However, some youth find unique ways to work through "ecogrief" (Ojala, Cunsolo, Ogunbode & Middleton, 2021) and still engage in ecological hope (Verlie, Clark, Jarrett & Supriyono, 2021). While some scholars refer to ecological hope as a feeling or emotion, and suggest instead we strive for efficacy, which leaves students feeling empowered (Ray, 2020), the definition of hope implied in my paper draws on Paulo Freire's ideas of "*Esperançar"* (1992) and "active hope" (Verlie, Clark, Jarrett & Supriyono, 2021). These definitions of hope are not merely a state of emotional optimistic waiting but are distinguished as an active refusal to wait in "*este mundo de mierda está embarazado de otro*" (Galeano, 1971). In this paper, hope allows for imagining outside of colonial and settler logics (Freire, 1992; Diedrich, 2016) and, in doing so, disrupting underlying systems of oppression and violence. And "Ecological hope" is the optimistic fight for these unborn or unrealized possibilities beyond the Anthropocene. (I want to pause here to acknowledge that throughout this paper I use the term "Anthropocene" to stay in conversation with others who recognize that human activities have created ecological changes/crises at a geologic planetary scale. But I use the term hesitantly because not all humans

are responsible for these crises and this word further invisiblize and shields the real culprits, colonization, and capitalism (Noel & Adsit-Morris, 2020; Liboiron & Lepawsky, 2022).)

This paper dives into these issues by featuring a youth environmental education program in Bahía de los Ángeles, México from 2020-2022 focused on reducing local marine plastic pollution. The program was hosted by the Vermilion Sea Institute and ran by several staff and scientists living at the field station. The Plastics Project developed students' understanding of marine pollution and degradation issues and evolved into the youth becoming scientists and leaders of a local plastics study. They collected and analyzed micro-macro plastics samples for The Big Microplastics Survey, shared their work with community members and visitors, and advocated for local solutions. Idra's introduction into this work represents one of the many ways that the youth metabolized harm to the ocean—physically, and emotionally, breaking harm into compostable chunks that then can be used as energy, nutrients, or inspiration for authoring ecological hope as the Plastics Project unfolded. To capture other youths' varied responses and engagements, I use a critical qualitative case study approach to construct three cases (Madison, 2020; Patton, 2003; Merriam, 2009) which provided insight into how participating youth (1) emotionally responded to learning about issues of marine destruction and (2) the sources of ecological hope and motivation they drew upon throughout the Plastics Project. Through this study, I aim to identify ways science educators (formal and informal alike) can better support students in bearing witness to and sustaining ecological hope in the face of environmental atrocities. This is essential work given that many teachers are at a loss for how to support students (Verlie et al., 2021; Phikala, 2020), causing many to avoid teaching about environmental destruction.

Literature Review

Pursuing these ideas from a critical sociopolitical historical lens revealed contexts that sculpted the youth's connections to water, responses to ecological violence, and moments of ecological hope they authored. In this literature review I carry this critical lens forward to problematize arguments that ecogrief should be avoided. Additionally, I argue that it is unhelpful to dichotomize ecogrief and ecological hope. Then I pivot toward hope, synthesizing what is already understood about how youth (and adults) create or sustain ecological hope despite the ongoing atrocities of the Anthropocene.

Ecogrief Is Not Something That Can or Should Be Avoided

Many youths already have personal experience with ecoanxiety, ecological loss, and ecogrief (Verlie et al., 2021; Pihkala, 2020; Ojala et al., 2021). Those living along coastlines, whose families depend on sustenance fishing/aquaculture, or who are Black, Brown and/or Indigenous are disproportionately impacted by issues of environmental injustice (Cunsolo & Ellis, 2018; Robinson, 2022). Climate education researchers Blanche Verlie and her colleagues add that all youth are particularly vulnerable to ecogrief as they come to understand that the ecological problems of today will be the crises of their future (2021). Therefore, ecological loss and issues like the climate crisis or marine pollution must be understood not as problems of the future, but the present. Environmental catastrophe has already snuck past every line of defense and is living flagrantly among us.

However, an encouraging tangential theme of these reports is that youth awareness of environmental problems and elevation of effective actions tends to increase motivation to address the issue, rather than elicit apathy or disengagement (Taber & Taylor, 2009; Verlie et al., 2021; Pihkala, 2020; Shume, 2015; Ojala et al., 2021). Careful framing of environmentally consequential learnings is also vital for avoiding helplessness and demotivation in young youth (Anderson, 2012). For youth who do receive carefully designed opportunities to discuss and learn about climate change, they are more likely to care about the issue and feel significantly more assured that the problem can be prevented or mitigated (Pihkala, 2020; Verlie et al., 2021; Taber & Taylor, 2009). Additionally, another study found that teenagers who were worried about environmental problems behaved in more environmentally friendly ways (e.g., not littering) (Hokka et al., 1999). Maria Ojala and her colleagues explain that this motivated response to anxiety and worry occurs because these feelings are part of the human defense mechanism (2021). Worrying creates preemptive space for creative thinking, problem solving and preparation to face what will come (Ojala et al., 2021; Levrini et al., 2021), solutions which can help protect our Earth and increase possibilities for healthier tomorrows.

Collectively these findings demand that educators move beyond their own fragility and fear of cultivating ecogrief to center issues of environmental injustice and our children's futures.

Personal Connections and Histories Define Youth's Responses to Environmental Injustice

Meaningfully engaging youth in these topics necessitates that learning occur at the nexus of place, environmental science, culture, politics, history, and personal connections (Shume, 2015). While each of these lenses are vital, none is more salient than designing learning to be personal and relevant (Martin et al., 2015; Bang, 2020). All youth have connections to nature, including marine settings, even if these are hard to identify. However, youth who grew up, or whose family or cultural background ties them to nature in undeniable ways, have a more complex relationship and vibrant history to draw upon and attend to when learning about the environment (Stromholt & Bell, 2013). Educators must realize that the more personal a topic, the more diverse, consequential, and self-determined youths' responses will be.

As some scholars have feared, these emotions often do not align with what is expected or accepted by adult educators (Ballard, Dixon & Harris, 2016; Grauer, 2020; Schusler, Krasney, & Decker, 2017). The same problematic parameters and expectations that educators place on what it looks like to engage in science (Bang, 2020) exist for youth learning about environmental destruction and injustice, including emotional stoicism (Wölfle Hazard, 2022). Too often educators try to control how youth emotionally, or intellectually, respond to studying nature (Verlie et al., 2021; Pihkala, 2020). While some responses align with, or conform to these ways, others display individual or culturally diverse ways of processing their learning (Bang, 2020; Carlone & Johnson, 2007; Brandt & Carlone, 2012; Brickhouse, Lowry & Schultz, 2000). Sometimes this appears as youth folding into themselves, growing silent or apathetic, others become vocally or physically angry, bitter, or even aggressive. Moreover, when students of color, particularly Black and Latina girls, act in self-determining ways these responses are far more frequently labeled as "inappropriately aggressive or angry" (Evans-Winters & Eposito, 2010; King, 2022; Fordham, 1993) Welcoming diverse responses is vital for avoiding the suppression of these powerful emotions, and, as science educators Natalie Davis, Shirin Vossoughi and John Smith (2020) argue, for nourishing youth's sense of individual personhood and bridging intellectual activity with their individual developing identities.

Approaches to Metabolizing Ecogrief and Other Negative Emotions

Not to be overlooked, youths' responses are also shaped by the approaches (conscious or subconscious, individual or communal) they have access to for metabolizing their loss and other ecological emotions. Metabolizing grief, like food, means to break these losses down into

manageable pieces and use the energy that is released, or remaining minerals, to build something new. If grief goes unmetabolized, there is no fuel for change. This metabolic process provides the energy and foundation needed for finding hope and then engaging in activism, advocacy or simply imagining the future. In *Affective Mapping* Jonathan Flatley goes a step further writing that melancholy, which can be understood as a form of grief, is not innately bad—rather melancholy remaps a road for relating with the world that extends from the longing of something no longer here (Flatley, 2008). Similarly, in her series "*Questions for a Resilient Future"* Manón Voice writes, "loss is part of the contract of living" (2022).

Therefore, the approaches youth use to metabolizing their learnings so they do not drown in ecological sorrow and have energy to hope can be equated to tools of support. Science education researchers Angela Calabrese Barton and Edna Tan (2010) emphasize that tools influence who people are, who students are becoming and the iterative nature of identity formation. Applying this lens can be helpful because these tools can guide educators in the vital work of cultivating ecological hope. Unfortunately, little is known about what teachers should do outside of providing space to discuss ecogrief and accepting students' varying responses (Verlie et al., 2021; Davis, Vossoughi & Smith, 2020; Pihkala, 2020; Ballard, Dixon & Harris, 2017; Griffiths & Murray, 2017). The paucity of literature on ecological hope, especially within education, reverberates loudly. So, what *does* the literature offer about ecogrief?

Critical community can help metabolize ecogrief. We know that being in a community of allies creates space for safely acknowledging and processing ecological harm—which validates the complexities and challenges of these issues, as well as reduces feelings of being overwhelmed or isolated (Fedrici, 2018). Furthermore, youth who interact with trusted societal actors on environmental issues receive constant subconscious reminders that they are not alone and others (often with more recognized influence and therefore potential to realize change) are committed to creating solutions (Ojala et al., 2021). These multigenerational coalitions of friends, family members, and other community leaders help pull youth out of isolated sorrow toward designing for their current and future families (Van Horn, Wall Kimmerer & Hausdoerffer, 2021).

Relationships and connections with nature help metabolize ecogrief. Additionally, since time immemorial Indigenous communities have understood the importance of deepening nature-culture relationships (Medin & Bang, 2014; Cajete, 2000). Time and connection to nature

and place fosters provocative wonder, which may have a healing effect (Nxumalo, 2022) because by starting with the more-than-human, we can begin to imagine solutions that serve all forms of life and address the deepest wounds (Robinson, 2022). Also, developing awe and respect for nature creates space for believing that nature is powerful, resilient (Whyte, 2018), and capable of healing Earth.

Expanding knowledge and skills help metabolize ecogrief. In this final approach, youth learn new knowledge or skills (particularly hands-on) that are relevant to the environmental problem or solution. The process of mastering a new learning can be temporarily distracting and help increase youths' confidence and agency toward making autonomous decisions regarding the local environment (Ballard et al., 2016; Briggs et al., 2019).

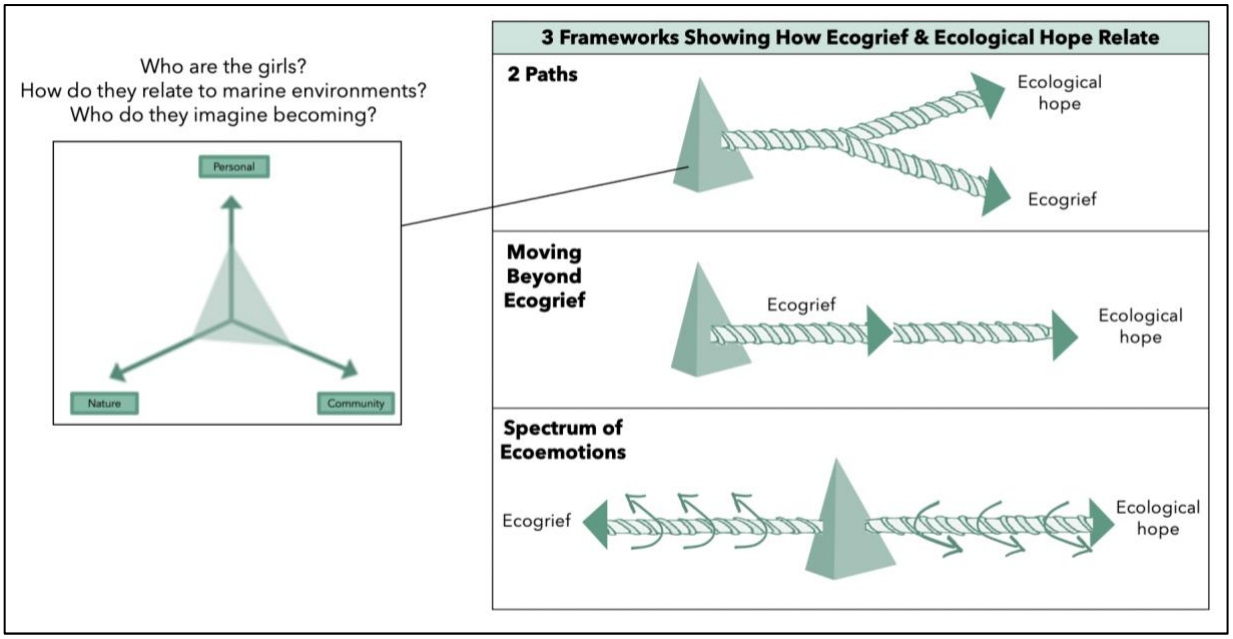
Conceptual Framework

Considering these constructs, I originally drew on Place Attachment Theory (Haywood, Parrish & He, 2020) to recognize the multiple dimensions/influences of/upon identities (personal, community, and nature) as related to a place. Place Attachment Theory served as a tool of analysis for understanding how the youth interacted with the local marine ecosystem and responded to environmental degradation. Examining the data through an identity lens of personal, community and nature (or more specifically the ocean) visiblized how, when, with whom and why students were experiencing ecogrief and ecological hope. By tracking how different dimensions of their identity were impacted, I was able to consider what moved them toward ecogrief or ecological hope.

As shown in Figure 1, current scholars disagree about ecogrief, and ecological hope relate. Ecogrief and ecological hope used to be portrayed as different paths a person can take in response to environmental loss. More recently, ecogrief and ecological hope have been theorized together and are either framed as chronological (with people needing to "work through grief first") or as opposite emotional states along a connected spectrum, with little in common and never occurring simultaneously in one person.

Figure 1.

Rethinking How Ecogrief & Ecological Hope Relate



A goal of this paper is to challenge all three of these frameworks, but especially the dichotomy presented as a spectrum and more deeply understand how ecogrief and ecological hope relate to each other and youths' identities. Additionally, to better understand ecological hope as an active verb, I wove together identity authoring literature (Holland et al., 1998; Johnson et al., 2010) and the concept of "worlding" (Haraway, 2016; Mitchell & Chaudhury, 2020; Lakind & Adsit-Morris, 2020; Akomolafe, 2020). Using these frameworks was important as hope is always impacted by who we are and how we interpret the world and hope always authors a different future.

Identity authoring is the formation of past, current, and future versions of oneself in fluid, resilient and creative ways (Holland et al., 1998; Johnson et al., 2010). It is Angela Johnson and her colleagues' description of authoring as, "action that resists and undermines structural constraints resulting from a subordinate location in the matrix of oppression" that most deeply informed my own ideas of how "oppression shaped, but did not cement, authoring opportunities" that the youth had (2010, p. 344). While these definitions are generatively situated in systemic forms of oppression, Potawatomi climate activist and scholar Kyle Whyte extends authoring beyond "self" in important ways to consider how some people have been denied their "ancestral

fantasies" of futurity, often through forms of colonialism and/or environmental detachment (Whyte, 2018).

When individuals and communities imagine new futures "that exceed white visions of 'the' end of 'the world' (Mitchell & Chaudhury, 2020), they are engaging in "worlding" (Haraway, 2016; Climbing Poetree, 2017; Akomolafe, 2020; Lakind & Adsit-Morris, 2020). This speculative practice is rampant among science fiction writers but also social and environmental scientists and revolutionaries. As Jesse Bazzul & Sarah Tolbert explain about worlding, "imagination and love become forces that make different possibilities visible" (2019, p. 307), and I argue possible. Although expansive visions are important, in a study of Italian youth, Olivina Levrini and colleagues found that youths' ideas of the future become more action-competent and probable when supported through inquiry, epistemological, and conceptual knowledge scaffolds (2021). For youth worlding against forms of environmental degradation and eco-apocalyptic or post-apocalyptic narratives (Whyte, 2018), this authoring of new selves and worlds is yes informed by science constructs and skills but, equally importantly, is a radical form of identity formation, performance, agency, and environmental activism (Whyte, 2018; Holland et al., 1998; Johnson et al., 2010; Lakind & Adsit-Morris, 2020). As discussed later, the findings of this paper suggest that the impacts of ecogrief never fully dissipate and that as we author new worlds ecogrief and ecological hope eddy together to create this otherwise.

Methods

Since April 2020 I have employed a critical participatory ethnographic approach (Carspeaken, 1996; Anderson, 1989; Madison, 2020) to this work by engaging as both a researcher and project partner. This approach exposed consequential connections to the ocean, community and environmental injustices that otherwise would have remained veiled (Anderson, 1989; Madison, 2020). Additionally, this methodology supported collaborative research where participants helped create objectives, tools, and outcomes of the research, which in turn helped me see their diverse forms of participation, ideas, tensions, and desires (Calabrese Barton & Tan, 2010).

Setting & Context

As previously mentioned, this research is situated in a local youth environmental education program at the Vermilion Sea Institute along the Gulf of California. The program began when staff recognized that access to the world-renowned archipelago (UNESCO, n.d.) was inequitably favoring visiting scientists from the United States. Once created, the program filled a missing niche in the community as the only afterschool or summer youth program. Participating youth learned alongside marine biologists about local marine and terrestrial ecosystems and human impact on these places. They also engaged in conservation research related to some endangered species in the area (ie., whale sharks, sea turtles, etc.) and marine plastic debris.

My own positionality as an outsider-insider (Banks, 1993), or as one of those privileged visiting scientists from the United States, is important to note. Adding to this complexity is my now 10-year history with the Vermilion Sea Institute. I first visited as a student pursuing their Master's in Teaching Biological Sciences in 2012 and then returned as a volunteer educator to build the program and Plastics Project featured in this paper. Admittedly, I returned set on expanding who had access to the bioreserve, who conducted research and what happened with the data collected on local places. It is also important to share that as the project unfolded and took on increasingly heavy issues of marine destruction, my own ecogrief surfaced from years of teaching environmental science and simply being a human living among during planetary crises. Together these different parts of my identity influenced and limited what I noticed, what was shared with me, how I analyzed data and which stories I chose to retell. However, my positionality also made the work what it is "a fight for the next best possible future" (Johnson, 2020).

Participants

Of the thirteen youth involved as leaders on the Plastics Project, only those most interested in the research process (n=6) choose to engage in extensive critical ethnographic interview cycles spread across five months. Since I wanted to create thick descriptions of the youth (Geertz, 1973) and do justice to what they shared (Madison, 2020), three youth participants are featured in this study. The middle and two high school youth were chosen because of how they engaged in the program, the diversity of emotions they shared about the

Plastics Project and environmental degradation more broadly, and lessons they can teach us about living during the Anthropocene.

It is not coincidental that all three of the participants identify as female. One of the early program objectives had been to support girls in the community in engaging in the program and one strategy was to create "a girl boat", where the few female participants could safely discuss girl/womanhood and develop a community of strong conservation-oriented women. I mention this because multiple parts of the cases shared below occur on the "girl boat", where surrounded by community, the girls seemed empowered to engage in the program without inhibition. It is also important to note that in the case of Lia, she is paired with program leader Romina because her experience being in the program, processing ecological grief and taking up conservation work cannot be parsed from this relationship.

Data Sources and Collection

As this is a critical participatory ethnography, my goal was to stay "open, creative but also rigorous" (Carola Orozco-Suárez, lecture March 2020) while collecting data. Therefore, the sources of data and initial methods evolved reflecting the collaboration between myself and the participants (see Appendix A for data collection timeline). Below I briefly describe each data source and general methods used for collection.

Field observations. During late spring and summer of 2021, I permanently lived at the field station and shifted from a remote partner to a local critical participatory researcher. This allowed me to collect first-hand observations of the program which provided otherwise unattainable insights into how the students engaged and processed their learning (Wolcott, 1994; Emerson, 2011; LeCompte & Preissle, 1993). To minimize researcher lurking, I kept inconspicuous "jottings" in a small notebook mixed with our team data or on scraps of paper in my pockets. Then, following the suggested technique of Emerson (2011), I elaborated on these observations during private breaks. Each evening I then documented these noticings in detail using a Google Form (see Appendix B), adding photos, audio clips and other related artifacts and added to my personal journaled thoughts and reflections on the day.

Ethnographic interviews. Audio recordings, jottings and transcripts of all ethnographic interviews were collected as primary sources of data (Patton, 2003; Emerson, 2011). Using a semi-structured interview protocol, I conducted three to eight 30–90 minute formal interviews of

all youth spread across five months. Each interview focused on a specific research objective and rationale (see Appendix B). During the last interviews I used a lose photo elicitation technique to facilitate the conversation (Clark-Ibañez, 2004; Holtby, Klein, Cook, & Travers, 2015). To do this I selected photos in advance to ask the students to reflect on or talk about. These were photos that were taken between May 2021 and August 2021, often out in the field when we were collecting microplastic samples. Additionally, I had hundreds of spontaneous informal conversations with the youth, which occurred concurrently during field observations. Guardians, staff, visiting scientists and educators also participated in open to semi-structured 20–150-minute interviews (n=22). After each of these interviews I followed a similar procedure as with the field notes—recording key moments, quotes, follow-up items/questions, or themes from the interviews in the Google Form and then journaling about these conversations.

***Program Artifacts*.** Photographs, students' official conservation logs, student surveys, artwork, models, field notebooks, and other relevant artifacts I compiled from student files at the station going back to September 2020—before the students even began the Plastics Project. These were used occasionally during interviews but more often provided background and context on each student and what connections they were making to environmental degradation before the Plastics Project began.

Data Analysis

Critical ethnographer Soyini Madison (2020) explains that she knows it is time to start analyzing the data when "my most pressing questions are evolving into thickly described stories that are beginning to require some attention and deciphering" (p. 49). By weaving together data collected over 16 months, with particular attention to focal interviews and observation data collected during the Summer 2021 Plastics Project, I created multimedia portraits (Carlone & Johnson, 2007; Tan et al., 2013) representative of the six girl participants. Taking a cue from the analysis conducted by Tan et al. (2013), these portraits included focal participants' stories about their current and future selves, family/community and science, connections to nature and participation in the environmental science program. By organizing what the girls did and said (Carlone & Johnson, 2007; Tan et al., 2013) around themes of (a) who am and (b) who I am becoming (Thompson & Windschitl, 2005), it was possible to attend to the different dimensions of Place Attachment Theory (Haywood, Parrish & He, 2020) and identity authorship (Holland et

al., 1998; Johnson et al., 2010; Akomolafe, 2020) to create a full image of who these youth were/are. (See Appendix C for example portrait.)

Once portraits were created, I conducted subsequent rounds of open-coding and revising of the portraits (Emerson, 2011; Merriam, 2009; Tan et al., 2013). While clarifying existing codes and subcodes, I refined hypotheses and confirmed or disconfirmed these based on the coded evidence. During both open-coding and line-by-line focused coding, I kept coding memos and used Word's comment feature to track and organize emerging themes (Emerson, 2011). Throughout the analysis I took a critical interpretivist approach and privileged the youths' meanings, perspectives, and realities above my own or other adults' interpretations (Crotty, 1998; Carlone & Johnson, 2007)—a method consistent with other critical participatory ethnographies (Madison, 2020; Martínez-Cano, personal communication, 2020). However, it was still important to have stories confirmed, refuted, or complicated by varied perspectives. To show reliability and validity, secondary interview data from Aventureros staff, guardians and schoolteachers were collected and triangulated against focal participants' interview and observation data (LeCompte & Preissle, 1993; Merriam, 2009). Moreover, during the final interviews, I shared the portraits again—which gave participants the opportunity to tweak, redact, expand, or (re)narrate their story. Positioning participants to assist with interpretation of their own stories was unquestionably messy, but would, once again, help center the girls' own world views and engage them in meaningful self-reflection (Patton, 2003; Madison, 2020; Holland et al., 1998).

Findings

The following three cases introduce four essential members of the Plastics Project (three youth and a marine scientist working as an environmental educator). Understanding their unique histories and connections to the ocean, as well as how they each understood the ocean as a teacher, gives context for how the participants responded to learning about and combating marine pollution. Collectively, their stories illuminate that ecogrief and ecological hope are not dichotomies that exist separately. Rather, these eddy together in estuaries of noticing environmental degradation to author flourishing futures and beautiful identities beyond the Anthropocene.

The Case of Amaya

At 14 Amaya was a good friend, philosophical, athletic, ferociously stubborn, inquisitive, and always the underdog's advocate. When asked, Amaya described herself as "someone who worries a lot---I'm a nervous wreck most days! Uhm, I would also say that I am kind--you know, I try to be caring. Also, I am---------- introspective?" Her mom, Rosalia, confirmed this confiding, "she analyzes things to death" and then sheepishly admitted that this was an inherited trait. At times this obsessive anxiety hindered how she related with her peers but, like her mom, Amaya became a loved and appreciated member of the group. She had moved from Mexico City the previous year when Rosalia became the head of the local national office (CONAP), responsible for protecting the nearby marine bioreserve, where she granted and revoked permits and was often the unliked enforcer of conservation regulations. And in this small fishing town, Amaya was judged by association.

Under her mother's influence, Amaya had been raised to live with a relentless dedication to knowing and caring for nature, which quickly transferred to the marine world when they moved to the bay. In contrast to Idra (who opens the paper), Amaya often volunteered to do more plastic analysis or sacrificed personal time to assist with extra setup or cleanup after long days—another trait passed down by her mother, who showed up exhausted to evening community meetings ready to brainstorm solutions to the plastic problem, support her daughter's interests and continue in her role as a protector of nature.

The ocean as teacher and place of unexpected lessons. Amaya loved being near the water and, as an avid learner, she was constantly intrigued by the ocean. When asked why she liked the program she compared her learning in the program and ocean to learning at school—where they learn inside, alone, and from pictures.

> We are in a room, and we are all sitting and writing, and our teacher is like, 'What is this? What is this?' and we almost can't ask her questions because it's like asking her everything and she just gives us all the answers— 'You learn it now.' You have a year to learn it, all this, and 'you must learn this and this', but within an hour here I really feel less stress and we learn a lot of things and I find myself wondering a lot of things sometimes, that's the difference, that's a big difference—I feel freer to ask questions and learn than at school.

With a similar sentiment, earlier in the summer she told a group of adult scientists:

> I feel like there are many things in front of us. Flying under our noses that we haven't discovered, and the ocean has a lot of things that it can teach us. The thing is, I feel the ocean can teach us something. To do something. To understand something.

While it was unclear what lessons the ocean was teaching, in a private conversation with me, she acknowledged that this learning was not about species names or other arbitrary facts but instead gave the example of seeking out the same fish repeatedly over numerous days.

> I realized that the fish helped me a lot even though I didn't listen to him. I didn't understand him, but it sent me a message that no matter how small you are or how big you are, you can accomplish big things without even talking, without even listening and without even seeing.

Reverence for her teacher, the bay, was an inherent and accepted truth for Amaya. In turning to this source of wisdom and life, she learned more than she hoped to and in ways that made her feel accepted as is and cultivated a radical form of ecological hope.

Recognizing marine destruction, resting in ecological hope and authoring worlds beyond the Anthropocene. The ocean wasn't Amaya's only teacher, her own mother passed along lessons about identifying as a part of nature, recognizing ongoing ecological violence, and understanding the world through the perspective of other species. For example, because of her mother, Amaya's life had forever been saturated with recognition of environmental destruction and her own obligation to nature. Of all the kids, Amaya alone checked the brands of sunscreen for coral-friendly labels, waved off offers of plastic wrapped candies, and listened intently when permits or regulations were mentioned. She followed the rules, desperate for these to succeed at protecting the ocean she saw being harmed.

> I compare myself a lot with her [nature] because we have many things in common--- I'm not going to tell them; they are personal matters. There is too much twisted------Well, listen, [nature] is really an innocent, you could say. Then we came like pests and destroyed everything in our path, and really nature is not to blame for anything—*How* do I have a connection with nature? I think I don't really know, but I do feel a connection, but I don't really know how to explain it. It's like I put myself into the water and one time I said to myself I don't know, I'm going to try, I don't know, to let go of everything and just think about the movement of the water. I didn't get all the way in, and I was just moving, and I feel connected when I let go completely. I let go and stopped thinking about all my worries.

This awareness of the marine world, its innocence and the extractive violence enacted upon it flooded Amaya's everyday realities and at times was too big for her, and her mother, to hold.

> What does it take? Let's say that we should really open our eyes to humans, because we can think we are in control of harming them, 'I can throw this away, surely a fish will eat it and it will just be a fish'---but it's a life! The problem with humans is that they don't realize that by harming the ocean, we are harming ourselves, it's a chain that if I harm this one thing, it always returns the pain—Well, let's say we decide 'we're not going to hurt ourselves, nothing is going to happen to us if we throw this straw in the garbage can, but then it's going to fly in the air and go into the sea. And I tell you, it is like the butterfly effect, one little thing makes a big change, a big difference, something big goes wrong. I say this but I also know saying this is not right--I know this is not a butterfly effect, because we throw away so many straws a day here. How many people drink frappés every day? How many people drink lemonades over there in Alejandrina's? And I say now, multiply it by the country, then multiply it by the other countries that are around and then the whole world. So, I say there's no small effect, like with butterfly wings-------When I put it that way, it seems impossible to solve.

Fortunately, Amaya found a community of friends and adults to help counter her weighty and "impossible" world. Both Amaya and her mom shared at different times that the plastic project and program had transformed their solo battle to process ecological violence into one with friends and allies encouraging them to continue laboring in towards environmental justice. One day Amaya acknowledged this community to adult visitors helping with the project:

> I was so new [to the town/program] that they weren't going to let me join. So, I begged. I mean really, like crying and whining begged to be a part of the group. [Why did you care so much?] Learning, I just love learning! But also, I feel like sometimes I'm a person who loses a lot of hope in things, and I feel like maybe by doing this like maybe I can change my view of the world and maybe I can still think that there's hope to change it and to be able to clean it up from all the plastic that's in the sea and everything…And now, my best friends are here and for the first time I belong, even if they make me mad sometimes, I really enjoy them all. Together anything is possible, and I am encouraged people do care.

Collective caring and action helped cultivate faith in the potential impact of their plastic research, where Amaya was meticulous about data collection. She micro-managed each step to ensure that the data was collected *perfectly*, every piece of trash picked up and others' behaviors policed–Amaya had found a productive outlet through the project for her feelings of ecogrief and anxiety. While annoying to peers, and even adult volunteers occasionally, this obsession reflected her knowledge of the power accurate and dependable data could have–a lesson learned from her mother's own fieldwork.

Along with finding a community of allies, it was Amaya's time in and with her teacher, the sea, that cultivated hope. During water time, between collecting samples, she would morph from a high-strung scientist into a serene mermaid—freediving, far beyond other students. Other times she would play at holding her breath for long minutes at a time. And without exception, the longer she was in the water the calmer and more liberated she became. Like her mom, who would get lost looking into the ocean, it seemed in her DNA to be healed by intimacy with water.

Kelsie: A lot of times I have seen you in the water and you are diving deep and when you come up you have a giant smile or on the paddle board with Gus and Lia, and say, 'I'm with my friends' and you looked so happy.
Amaya: I am but I am not. How can I tell you? I like sometimes, as Romina says, 'I like to go deep', it's like being alone, but I don't get too deep. Well, I do like it, I like to look down. How do I tell you? I like to go far and swim as far as I can while holding my breath and it's like holding all that (motions toward the bay). And sometimes when I go with Lia I get in and we're seeing fish, we're seeing everything.
Kelsie: Yes.
Amaya: I don't like having my head up. When it's underwater it's like forgetting everything—Just concentrate on seeing what's in front of you.------So yes, I prefer it [the water], because one time I went down below and there were fish and they were looking at me, and sometimes I feel that a person who doesn't speak understands me more, because its' not that it's bad that he's interrupting me, but I feel that it's listening to me. The problem with humans is that sometimes they don't listen to me. It listens—better than most humans and I feel that nature has many qualities humans don't have.

It was not uncommon for Amaya to turn to nature or multispecies intelligence to sustain this hope. Afterall, her mom had raised her to find wisdom and solace in more-than-human species. For example, Rosalia, who was known in the community for healing injured animals, told Amaya and I one afternoon that we only had to pay attention, and think like the animal (an electrocuted seagull in this case), to know its story, needs and future. This brief discussion mirrored Amaya's practice of "sometimes being a fish…observing them and trying to think as they do". This deference to more-than-human intelligences were another small clue, among many, that Amaya's connections to nature which allowed her to dialogue beyond her fears and grief—had been nourished by her mother, as well as the ocean.

Summary of Amaya. Ecological destruction weighed heavily upon Amaya from the first day she joined the program—anxiety, pessimism, grief and caution about the future, people and "the butterfly effect" of marine degradation ruled her deepest being. Unlike the other youth

featured, these fears manifested as obsessive rule-following and dedication to realizing viable solutions. However, with time to connect to the ocean and others on the project she became considerably more hopeful and functioned more frequently from a place of curiosity, intrigue, and inspiration. So, it wasn't only the companionship or distraction of the program or even the promise of positive change that comforted Amaya. It was her teacher, the ocean, and "the full mystery of it" that gave her sanctuary from ecogrief and a place to grow, listen, and dream of hopeful realities beyond the day's heaviness.

The Case of Idra.

Idra was a boisterous, lively 14-year-old, who dyed the hair that framed her face in fierce greens and pinks. She was a fast friend to all and distributed hugs and sass in equal quantities. As a very social person, Idra recruited many of her friends and cousins to join the program which positioned her, from day one, as the team's spokesperson—a position she embraced and felt comfortable with because "I don't get nervous talking to adults". She had grown up in a family of fishers who were leaders in town with their seaside restaurant and her grandmother who was a convincing protector of the bay. So, like her grandmother, mother, and aunts, Idra `was a natural, outspoken leader and the joy she exuded was contagious.

However, as easy as it was to be charmed by Idra, unlike the other students who idolized adults at the station, she could be outwardly dismissive of staff or scientists and bluntly said what she felt. In many ways Idra represented the angsty rebel teen trying to find herself, but her story and relationship with the ocean was much more complex.

The ocean as teacher and first love. Despite being a good student, Idra believed that no degree or schooling could replace learning from the ocean itself. One afternoon she shared…

> Idra: I think they, the scientists, spend their time on the computer and we are busy living in real life, and we've been experimenting with it [the ocean]. And it's true that we can explain it better and we can kind of tell it without any problem, to the scientists, but if you listen to us, we can be better than the scientists.
> Kelsie: I really agree with you. Do you have an example for me?
> Idra: Yes, for example, a scientist from the US was here. He was looking at whale sharks. Well, he's on the computer watching whale sharks, he's watching, and the

> computer is there. We went to see it and then we saw that the scientist didn't know much... Like, if its skin is scraggly, if it has a partner, how they sound, like what waters it inhabits, those things.

In this moment, Idra made it clear that no human teacher could ever replace learning from/in the ocean itself. “Humans are not kings…they do not know all and shouldn’t be treated like it, when they enjoy destroying things—there are animals under the sea that know better.” Admiring and acknowledging the ocean wasn’t just something Idra spoke to—she embodied this. For example, after long days in the archipelago collecting plastic samples from remote beaches, removing beach litter, snorkeling, and learning about whatever species presented itself, Idra would trot ahead of the exhausted pack to drop her gear in her locker before heading straight back to the water. She could never get enough of the ocean, and constantly craved to be in and learning from the sea. During one of these days out, a pod of dolphins swam alongside us, and we learned that cetacean scientists are known to dunk their heads overboard to listen to the symphony of clicks and whistles amplified by the water. Not letting a moment pass, Idra quickly launched her torso over the railing dunking past mid-chest. After a few brief moments hanging upside down she joyfully surfaced sopping and repeating the “eeee-ee” she had heard. Her boatmates’ congratulations went mostly unacknowledged as she continued to revel in the chatter. As with the dolphins, Idra took advantage of every learning opportunity the ocean presented and embraced her role as a student of the ocean. The first time I met Idra’s mom she teasingly launched into a story confirming that the ocean is an important fixture of her daughter’s identity and how she relates to the world.

> Her first word was not mama or papa! No, of course it was not! It was FISH!! Can you believe this? She was right out there, where the boat brought them in (points to a stretch of beach), she loved them so much and always has. She likes to watch them, learn about them, EAT them---and now she is swimming with them!

This story is a reminder that first words are important moments of learning but also grand gestures of love, care, and obsession–so it only makes sense that Idra’s word would be of the ocean. However, Idra never outright named her most important teacher or admitted her love

affair. Instead, she maintained a tough exterior and tried to make sure everyone knew she was interested in the ocean because she "wanted to study Great Whites. The most feared fish of all!" Only once in private did Idra confess that "the ocean is my safe place when humans aren't my favorite—I just love it". So, like others in this story, the ocean is inseparable from who she is. It is her first crush and teacher—bringing lessons of joy, wonder, stability, and a vision for tomorrow.

Recognizing marine destruction, resting in ecological hope, and authoring worlds beyond the Anthropocene. Idra's messages as the group's primary spokesperson, were always delivered with efficient, brutal honesty. She didn't shy away from naming how people in the room were contributing to marine pollution and its detrimental impacts. As evidence, once before leading a group of 22 visiting scientists and teachers through their plastics protocol in the field, Idra interjected the discussion with a sharp reflection on her growing consciousness of plastic pollution:

> I no longer see things the way I used to. Already when I look things are different. I was going to the beach without this, without any knowledge of the trash that was there. And now, well... I'm going to the beach to collect trash. And well, now I am angry about all of this. People need to do better and stop throwing trash in the ocean---look at how it is changing, killing, things. [her voice takes on an accusatory tone] Even since I was little and with my grandma and my aunt, there is more and more. We put this plastic, this trash in the ocean because we don't care and the fish eat it and we eat the fish and we will get sick… it is the revenge of the plastics!! [maniacal laugh and glaring] They're coming!

The stunned audience referenced this speech as "angry" or "pointed" and expressed surprise by her understanding of biomagnification and exposure indicators. These visitors gave Idra plenty of space but worked notably harder in the field after this comment—these adult scientists (who often consumed mindlessly and had brought gear, power bars, daily contacts and more wrapped in plastics into the community to be discarded) were also perpetrators of the Anthropocene and had had their culpability identified in front of all.

These moments of resistance and sharpness frequently bubbled up from Idra. At random times she would resist smiling in beach clean-up photos because "this is a serious issue" or she would refuse to help analyze survey data because "what is the point, when everyone is still throwing plastic in the ocean?" Another time, she happily got visitors started collecting samples and then giggling uncontrollably convinced her friends to run down the beach and do a swimsuit photoshoot with our project camera–when encouraged to rejoin her group she simply retorted "it's time other people clean-up, not just me". These tense acts of self-determination cast doubt on Idra, and the scientists and staff often described her as "a show girl…Very resistant to doing some of these things, like she thinks it is beneath her." It is true that Idra resisted, but "show girl" was a patronizing oversimplification of how she engaged. She was the team's most vocal advocate, the only student to attend every plastic research event and I caught her on many occasions pulling trash out of the ocean when she thought no one else was around. Idra was unapologetically herself, with the goal to "represent my family and everyone here and the sea—I want to talk for them and make them all proud".

Returning to the epigraph at the beginning, we are reminded of another time Idra pointedly acknowledged her love for the ocean and the animals in it but simultaneously labeled the project as connected with class (and garbage collectors/sorters) and called out the ecological burden passed down to her. In refusing to be scripted as a "trash person" by others, she authored an alternative (speculated) future studying healthy oceans full of sharks and other species worthy of her love, attention, and full self. These edits to her unconsented biography by the Anthropocene into a speculative autobiography raises questions about why she should have to be a trash person, but other scientists at the station get to study marine mammals and fish? Why didn't the youth program get permits for studying whale sharks like others? Why should Idra be restricted in what she can study because of the violent actions against nature by adults (who now act as gatekeepers to the bay and the wonders it sustains)?

Summary of Idra. Idra ended the summer grieving the marine destruction she saw everywhere. This isn't to say Idra was all frustration and helplessness because she most certainly was not. Her story is an honest and nuanced account of what it means to hold all the feels in a single tangle of tragic love, loss, and hope. More than the other participants, Idra voiced unsettling critiques about the Anthropocene—projecting her mourning but in this, making

persistent moves to author a new future for her ocean. A future where the ocean is better cared for, healthy and her own futurity isn't restricted by ecological wounds she didn't inflict.

The Case of Lia & Romina.

This case features youth participant Lia and program leader Romina together because their relationship as teacher-student, master-apprentice, and finally environmental justice allies defined Lia's story of caring for the ocean, metabolizing ecogrief and fighting for change. To ignore their communal story would be a dishonest betrayal that misses important lessons of what caring for the ocean amid ecological tragedy can, and should, look like in true community.

As one of the youngest members of the plastic study, who had lived in the community her whole life, Lia was surprisingly mature. She was a patient teacher and careful observer who was serious and innocent all at once. Her sharp intellect and mellow demeanor quickly gained her acceptance among the older youth and adults alike. For example, she was known among visiting scientists and teachers as someone who was surprisingly gutsy when necessary and "walks with a purpose—like she knows where she is going and how to get there". In contrast, Romina is a scientist who lived at the station and helped co-lead the youth program. At 30, she had traveled the world studying cetaceans and was creative, outspoken, and playful with almost everyone. However, she knew ecogrief well and it was not uncommon for her to ruffle feathers as she tried to hold others accountable to their more-than-human relations. Although very different, Lia and Romina are both incredibly intelligent, kind, beloved by the group and dedicated to saving the ocean. These similarities bonded them and turned them into close friends and allies.

Figure 2.

Hear no evil, speak no evil, see no evil. Idra, Lia and Romina playfully created statement art with trash found at the Quemado beach pickup site.

The ocean as teacher, growing multispecies caring and understanding through apprenticeship. Lia and Romina's relationship began with swim lessons that quickly turned into an informal apprenticeship where Romina spewed knowledge about the ocean and Lia eagerly soaked it in. Eventually, Romina invited Lia to join her on conservation projects at the community dump, extra snorkel outings and to sit in on university classes she was taking remotely. When asked about Romina, Lia said:

> She [Romina] has taught me many things about the sea, why it is good…It was whales, dolphins and things like that. And there she was studying and pointing and teaching me everything I know. There were so many things—I loved it.

With time their apprenticeship became more than a transactional exchange of knowledge or skills and the ocean became their mutual teacher. Their time in the water fostered new ways of seeing and caring for more-than-human beings—concepts that Romina quickly cultivated and centered in their time together. For example, Romina admitted,

> Don't laugh but I really love Lia, she is my favorite. When she comes over, I forget about a lot of the things happening and I can just be. There was one time I invited her here and we swam and swam for so long—just pretending to be mama and baby dolphin. [laughs] It was very silly. I *was* teaching her things about dolphins, but it was mostly just imaging and things like that. I can't be like that with the others.

The ocean's way of playfully but powerfully caring for others and being in this world transferred to Lia through Romina in observable ways. It was this way that allowed Lia to take startlingly clear photos of dolphins sprinting alongside our boat. "I just imagine that I am swimming down there, just like the dolphins. Then I can know where they will come up and how close or far they can be to the boat. You just need to think like them." Another time, Lia interrupted a presentation about their plastics study to adult scientists like a powerful typhoon striking emphasis that it wasn't only marine species impacted by the lack of a garbage management system but also,

> the coyotes, that are so hungry. From the drought we have, they come down and they---they--- ["scavenge" Romina filled-in] ---yes---scavenge the garbage floating around the desert near the dump. Do you think this is healthy? Imagine eating garbage because you are so hungry. We need a better place to put garbage that won't do harm to these animals.

Later Romina confirmed that they had seen the coyotes together and shared: "I am proud of her for saying that, because humans often just think about themselves or species, they have an interest in".

By the time I met them in-person, they had spent well over 100 hours in or near the ocean together and it seemed natural for both to see the world with more-than-human eyes, especially when they were together. It was not uncommon for them to derail conversations or plans to introduce stray dogs, point out jumping fish, sing back to birds, imagine the life of desert foxes, search for their stick bug friends, or help electrocuted seabirds. The ocean had taught them, through their apprenticeship, to approach the world with care for and understanding of more-than-humans.

Recognizing marine destruction, resting in ecological hope, and authoring worlds beyond the Anthropocene. Her time in the program and apprenticeship with Romina meant that Lia's life had become saturated in learning about marine destruction. When asked broadly what she has learned in the program, she was quick to say, "Well, I know more about garbage and what it involves and how it's done and everything." And like Idra, she talked about seeing marine destruction everywhere.

One evening, Romina received an invitation for the team to speak to about 60 Mexican tourists (ages 18-30) about the Plastics Project. Her first call was to Lia. After agreeing to come, Romina's own nerves were visibly soothed–she now had a dependable accomplice in the endeavor. Three other youth were able to come but this was one of their first opportunities to share their project and the audience was overwhelming, so they mostly stayed quiet. During the concluding Q&A someone asked how the group could help. It was their last day visiting and it was already dark, but the superficial offer was still uttered. Without skipping a beat Lia stepped

forward, projected her voice, and pointed to the table of plastic water bottles and food at her back and said,

> Well, all of these many water bottles that are yours—they are *all* plastic. Like what we find all of the time. You need to keep track of them! –That is what you need to do. Put your other trash in them, like the ecobrick that I already explained, and then make sure none of this gets into our bay. The ocean is not far, and the wind will carry it there if you don't guard it.

The group looked stunned as she finished and Romina failed to hide a smirk—here was her apprentice, really a baby in comparison to the audience, calling them out for their performative commitment to the ocean and insisting they pack out their trash. An enthusiastic leader murmured, "yes, let's do that and we can take our trash with us!" Our group knew the smell of trash in vehicles packed with people but stayed quiet as Lia nodded approval.

Like other symbiotic relationships, Lia and Romina's cares and work (ecogrief and ecological hope) were distributed across the pair so neither had too much to bear individually. As someone who had dedicated their life to conservation, Romina was skeptical of people, although her bubbly personality initially masked this truth. However, letting Lia follow her around "a bit like a puppy" was an easy decision because

> She has become like my sister. I can tell my science knowledge to her, and she cares and—well, she makes it so I can have some hope in this young generation... You know she wanted to be a fashion designer and now she wants to be a marine biologist? She has changed so much, and this gives me hope. I can't stop caring about all of this (waves at bay) because I know she cares, and I want to make things better, even just for her.

An example of sharing this burden occurred during the first boat trip of the spring. The youth were headed out on a panga to a remote site on Coronado Island to conduct their plastic survey when Lia's voice rang out above the chatter, "BASURA! Derecha." Her command mimicked directives Romina gave on land "Trash. Trash on your right." The difference was

Lia's command was directed at a male adult boat driver 35 years her senior, not some young teen. Her yell ensured all heard and cleverly left the boat driver with no way out— he wasn't about to crush this young environmentalist because his actions were now on display for everyone. As the boat circled around, Lia fished out the chip bag already thinned by the sun's strong rays and Romina shot her a proud look. Turning to me Romina mimed sobs of joy and quietly gloated, "Lia, she is my conservation queen—she is so on it!" Whether Lia intended to alleviate the need for Romina to flex her power, or not, it was evident that by enforcing care of the ocean she gave Romina solace that she was not alone in this fight for ocean justice.

Later in the summer, with 31 surveys completed, Lia shared that she was excited to use this information to determine what beaches need more maintenance. Like Romina, Lia was already plotting how to use the data to prioritize clean-ups and recruit more community help. "Now we are going to have information about our beaches, and we are going to be able to know. 'This one needs a little more maintenance than the other one. First, we need to focus on this beach and clean it and then we go to the other one that has less plastic. And so on.'" The words could have been Romina's own—again, evidence of Lia learning from Romina and, more importantly, sharing the task of authoring real change.

Summary of Lia and Romina. While both individuals were alarmed, frustrated, and discouraged at times by the ecological destruction they witnessed, this apprenticeship cultivated collaborative ways of carrying ecological grief and hope and fostered radical forms of worlding. As evidence of this, we see that when they were together, they both had invigorated and motivated responses to ecological destruction. They also beautifully co-authored hope in the ocean and its more-than-human beings by undertaking intellectual or physical challenges and outright activism.

Discussion

Considering the recent push to elevate marine sciences (Visbeck, 2018; Martin et al., 2015), outdoor learning experiences (Learning in Places 2021; Sobel, 2004) and to teach explicitly about the "Anthropocene" the three cases provide important insights into what diverse connections to nature, specifically marine environments, may look like among Mexican girls living in a small fishing community. Their responses to learning about marine destruction (1) disrupt the dichotomy often assigned to grief and hope, (2) urge scientists and science educators

to abandon emotional stoicism, (3) illustrate how youth author futures beyond environmental harm and (4) challenge who teachers are, and the ethic of caring teachers should embody when growing students' consciousness of ecological harm.

In general, across the participants we see gratitude, wonder, interest, and a deep respect for the ocean that was uniquely shaped by varied parts of their identity (in and outside of the program). The girls also shared ideas about what constitutes ecological violence and flourishing (Haraway, 2016). For example, Idra grew up along the shores of the gulf among fisher people and her past and future hopes were saturated with the ocean and her family's economic and cultural ties to the water. In contrast, Amaya's recent move from mainland Mexico meant she had few immediate ties to the bay upon arrival, but her deep intergenerational knowledge and respect for "nature everywhere" quickly cultivated care for the ocean. In the final case, we meet Lia who had spent her childhood blocks from the marina but had few personal experiences in or on the sea—her story is one fueled by curiosity for the ocean, respect for the creatures within it and her apprenticeship with Romina. These connections and ideas informed the participants' engagement in the program, their growing awareness of marine degradation and how they authored worlds of ecological hope.

Below I dive into the four key takeaways from the findings. I begin by synthesizing more of the feelings and connections that surfaced as youth engaged in the Plastics Project to highlight their stories of holding ecogrief not separate from, but always dissolved in, ecological hope. Finally, I build upon this analysis to outline a playbook featuring different ways the girls found rest from ecogrief and authored identities and futures otherwise inconceivable given marine destruction.

The Pelagic Zone: Ecogrief, ecological hope and everything in between co-exist

As illustrated in Figure 1, environmental educators often expect students to either drown in grief, becoming apathetic or depressed (Grauer, 2020), to "hurry up" and move past mourning to hopeful action (Ojala et al., 2021) or that they are functioning from a place of grief or hope, not both (Ray, 2020). Contrary to these dominant paradigms which dichotomizes feelings and experiences youth have while learning about environmental degradation, these cases present poignant evidence that youth simultaneously hold a diverse range of emotions related to the

Anthropocene. They aren't simply drowning in grief or floating with hope—they live in a Pelagic Zone with all the ways of being and feeling.

For example, many conversations with Amaya and Idra would rapidly oscillate between a wide variety of emotions. And, like their interview responses, the emotions they expressed while engaging in the Plastics Project also fluctuated wildly. One moment they would be conducting research or teaching others about the project, and the next they would actively refuse to participate as anticipated (like during Idra's beach photoshoot) because they needed rest from the depressing nature of the work or were simply busy authoring a fabulous escape. Their stories serve as a reminder that learning about environmental destruction can elicit an unwieldy range of feelings (Ojala et al., 2021)—which explains why supporting youth through processing ecological degradation can be so challenging.

Moreover, this pattern indicates not naivety, confusion, or shallow investment in marine pollution but, instead indicates that these youth had complex connections with the ocean they tried to attend to while grieving (Ojala et al., 2021; Wölfle Hazard, 2022). The three cases collectively teach us that ecogrief is not something people with deep connections to the environment move beyond—like the loss of a loved one, some form of grief always accompanied the girls, even in the most hopeful of moments. Cleo Wölfle Hazard (2022), a queer trans-ecologists, works from the "nexus of love and grief in ecological fieldwork" (p 146). He argues that the extractive settler logics that dominate ecology, field research and science more broadly have intentionally necessitated and trained professional scientists to hide away their ecoemotions from public and academic purview. This is because affectivity is necessary in dominant science for maintaining false notions of objectivity and validity (Wölfle Hazard, 2022). However, as discussed earlier, even when metabolized, parts of grief stay with us in forms of energy and nutrients that build toward wholeness, flourishing, and justice (Haraway, 2016).

So, rather than dichotomize youths' feelings and behaviors as related to ecological destruction, educators must anticipate that authentic responses will be "textured" (Gumbs, 2021) and that students are existing in a vast Pelagic Zone. Like open, expansive waters of the ocean, this Pelagic Zone contains a range of diverse and powerfully interconnected feelings. Furthermore, they should move beyond trying to control students' emotional and intellectual responses (Taber & Taylor, 2009; Ojala et al., 2021). While there has been some work by queer and feminist scientists to engage in "felt" science (Million, 2009; Wölfle Hazard, 2022;

Rodriguez, 2022), these emotionally charged ways of understanding, studying, and communicating about environmental science need to be introduced to youth. Mexican environmental ethnographer Yoallí Rodriguez recommends giving way to grief and the time needed to grieve and feel (2022). In her own work she sheds affectivity for methods and reasoning laden with "Sentipensar"—a Spanish word for feeling and thinking or feeling with the brain. This naming of our shared location in the Pelagic Zone, or emotions, is a powerful step in authenticity and collective sensemaking. This naming also aids us as a body of educators to understand learning as a site of becoming and learning as a site charged with emotion for who our students were, are and hope to be. Our youth carry scars from up-close encounters with environmental degradation and their expression of feelings (in whatever form) should be honored as radical acts of self-care, ecological brilliance, and solidarity building. Unlike the perception of some scientists at the station, youth are not blind to environmental destruction, they are already doing the heavy work of trying to author worlds beyond the anthropogenic harm—worlds worth hoping for.

Authoring other worlds of ecological hope

The girls' stories reveal students grappling with ecogrief but also students authoring a flourishing world, oceans, and personal futures—worlds constructed with hope and worlds worth hoping for. If we look more closely, we can better understand what allowed the girls to author these worlds and how this process provided participants rest and solace, despite their growing awareness of environmental injustices and marine degradation.

Fortunately, these unknown worlds can move from surreal to concrete in powerful ways. This happens because worlding is an innately sociopolitical cultural and intellectual act, and "noticing the world differently can have material consequences that could be the difference between taking care and perpetuating paradigms of oppression and needless suffering (Akomolafe, 2020). Therefore, just as current, and past identities are constructed through narratives, or tentacles (Haraway, 2016; Akomolafe, 2020), that at one time were speculative in nature, youth become their ancestors' dreams made flesh and then write their own dreams–dreams to also someday be realized. And when the dream is of a just world defined by socio-ecological flourishing (Haraway, 2016), capitalism, colonization, individualism, the nature-culture divide, and other actors of the Anthropocene must be unwritten.

Below, I analyze five approaches used by the youth to answer speculative science education scholar Ruha Benjamin's question about how we author the worlds we want (2022). Answers to this question are situated in who the girls said they are and who they want to become. For example, Amaya, Idra, and Lia construct radically new worlds outside of marine pollution by attending first to pieces of their severed or threatened identities related to the ocean and its health. The following list of lessons, or mechanisms, gives us insight into this question of how youth author ecological hope.

How to Author Ecological Hope: Lessons from the Girl Boat

1. Cultivate Voice, Critique, and Self-determination. Each participant at one time or another embodied their frustration, disgust, or sadness in poignant moments of critique. These moments of voicing righteous anger and holding others responsible for their complacency without regard for others' comfort were purposeful self-determined acts (Davis, Vossoughi, & Smith, 2020). For example, this occurred when Idra shunned beach clean-up responsibilities, ignored the research team, and accused visiting scientists of contributing to local marine pollution. It is important to note that during these moments she was not out-of-control, but the opposite—she stifled her bubbly, playful personality numerous times in lieu of taking a biting and angry tone or displaying dismissiveness. She was calculated. Temporarily severing pieces of her own identity to communicate her righteous anger. Although this authoring was often unpleasant for those on the receiving end, her feelings were all valid and reasonable, especially given that her love for the ocean and marine animals was transforming into ecological consciousness that made visible the tragedy of her first love. In naming ecological harm, Idra was recognizing societal failures and attempting to escape her reality by imaging alternative futures that weren't built upon her young shoulders.

Educators need to recognize these acts of resistance and "troublemaking", instead as healthy acts of self-determination (Davis, Vossoughi, & Smith, 2020) and authorship after identities are lost or endangered. If we understood hope as a form of fugitivity, and these responses as symptomatic of walking the earth during the Anthropocene and wading through the Pelagic Zone associated with environmental injustice, then we might develop more radically caring and generative ways of knowing and supporting Idra and the many youths like her. Additionally, we must work to normalize "felt science" and the transparent sharing of our

emotions through scientific work (Million, 2009; Wölfle Hazard, 2022) because emotion-laden critique and refusal of this world will always be first steps in authoring better worlds.

2. Center Intergeneration Human and Multispecies Relations. The relationships between Romina and Lia, Amaya and her mom, and even Idra and her extended family/friends, served as fuel to fight local marine pollution and author a healthier ocean. Each relationship, with its varying complexities and obligations, confirms the power of community in moving beyond ecogrief (Fredric, 2018; Ojala et al., 2021). Furthermore, these relationships teach us specific lessons.

We learn from Lia and Romina's intergenerational apprenticeship that dispersing the burden of environmental injustice across the relationship helps alleviate the weight of carrying ecogrief and imagining solutions alone. Having someone present who you care deeply about, and whose futures are tied to your efforts, add layers of obligation that can be distracting and beautifully freeing of any decision to disengage from the problem–disengagement simply isn't an option when someone you care about is at stake (Ojala et al., 2021). When intergenerational human relatives whom we love are centered, it becomes easy to dream of better worlds so fiercely that reality is bent toward justice (Tuck & Wang, 2018). Amaya presents another example as she felt a deep obligation to represent Rosalia well and her mother's endless dedication to protect the bay and faith in the work was a source of powerful conviction that encouraged Amaya to push past her ecogrief and act. Even Idra, who was rarely seen with others outside her own generation, was most content with the project when she was thinking about her family's connection to different sites along the bay or her grandmother's pollution advocacy. As someone who identifies as a very social person, it is reasonable that Idra's solace and motivation for attending to marine pollution and authoring other worlds stems from remembering who matters to her and upholding these relations.

Moreover, the girls' worlding extended to their multispecies teachers, friends, family and neighbors. Of the group, Amaya and Romina in particular, spoke of a deep gratitude for all that the sea provides–a gratitude they understood came with obligation (Van Horn, Wall Kimmerer & Hausdoerffer, 2021). Both talked of being indebted to the ocean and needing to make amends for the violent actions of humanity. Like intergenerational human relations, centering the sea helped them avoid apathy and served as a reminder of who to hold closest when fighting for marine

justice. Therefore, as youth author new worlds their imagining should be informed by who most needs to be prioritized and how to presence these beings.

3. Learn new Scientific and Embodied Knowledges. Each of the participants gravitated toward intellectual and physical challenges that arose during the Plastics Project. These challenges had a stabilizing effect on their emotional well-being (Ballard et al., 2017; Briggs et al., 2019) and served as tools of resisting this world which, in turn, enriched how they authored other worlds. For example, Amaya and Lia sunk into challenges that granted reprieve and helped metabolize their ecogrief. They mastered the names and facts of local marine species, absorbed scientific knowledge shared by visitors, and helped calculate and record the mass of plastic samples by racing the calculator with mental math. Lia learned to swim, snorkel, and eventually dive down, hovering above coral long enough to identify finger-sized fish. Amaya improved her snorkeling skills, learned to paddleboard standing up, and took lessons from Romina on free diving—constantly pushing herself to swim further and further distances underwater on one breath. Developing these new skills became a pleasant respite. Additionally, reaching different milestones became particularly levitating amid this project where tangible progress was elusive and the problem often incorporeal.

These challenges were often all-consuming and protected space for growth, wonder, play, and joy. However, not all challenges sustained an escape from ecological destruction. Idra illustrates this toward the beginning of the project when she thrived on the intellectual stimulation of explaining the project, its importance, and answering unexpected questions from visitors. This also happened when she turned sorting and documenting beach litter into a race between groups that was full of laughter and playfulness. But, as she became an expert, these once stimulating challenges staled, no longer providing a distraction from the gravity of marine destruction and her new vision of the world lost its novelty.

Although distraction is a benefit of these challenges, the girls teach us that more is happening here. Distractions won't unweave the ocean's trouble, but when distractions take the form of new scientific and embodied, knowledge the youths identities expand, and they are able to step into more agentic and public roles of refusing the Anthropocene.

4. Know the Ocean as Caring, Powerful Teacher. In authoring other worlds, Amaya, as well her mom Rosalia, and Lia and Romina, often took up the perspectives of different sea creatures or the ocean itself. This change in perspective was powerful because if we are to realize

socioecological flourishing worlds, more-than-humans (including multispecies and landswaterstarsairs) must be centered in future-oriented designs. For example, imagining life as a fish, stunned sea bird, or engaging in dolphin play were frequent occurrences. Sometimes this change in perspective was spontaneous, but more often it was intentional. Except for Lia, whose multispecies imagining appears to have been more instinctive than an intentional shift of viewpoint [perhaps this was because she was young and her ways of knowing had yet to be colonized (Glick, 2018) and "straight"ened to settler logics (Wölfle Hazard, 2022)].

The others all understood multispecies thinking as a muscle grown with practice, because refusing anthropocentrism isn't unlearnt overnight. Among themselves, they shared stories of practicing to become better listeners of more-than-human beings. Agreeing that it was most important to slow down and set aside human assumptions. They agreed it was important to undo extractive practices and to bridge the human-culture divide (Medin & Bang, 2014; Cajete, 2000). Different species, tides, the moon, sands, and other ocean entities possessed lessons of wonder, power, and knowledge that could became strong antidotes toward healing (Wölfle Hazard, 2022). Spending time learning from these different marine beings, and the ocean itself, brought profound ecological hope as they humbly realized the bounds of their human knowledge. They came to realize the ocean, and the many beings within its expansive boundaries, as powerful beyond comprehension and holding secrets to life and thriving humans have yet to discover. They were basking in Earth's strength and resiliency (Whyte, 2018). This state of humble wonder made it easy to imagine an otherwise and author a world ruled by the power and wisdom of the ocean, rather than humans.

Amaya and Romina carried this radical refusal of anthropocentrism and settler logics, a step further by coupling their understanding of multispecies perspective-taking with discourse about human violence. They believed that atrocities inflicted by humans against nature meant that humans couldn't/shouldn't be the primary healers of this ecological tragedy. Instead, in the futures they authored people deferred to more-than-human beings for radical solutions and paths forward (Robinson, 2022).

5. The Ocean as Model Teacher and Loving Editor. This fifth lesson elevated how the ocean was able to come alongside the girls to co-author, lovingly edit, and enthusiastically read the world. The ocean was a teacher who cultivated individual and communal solace and hope. And cared individually for them, showering them each with personal wisdom. For all the girls,

the ocean was a place they felt heard, held, freed, and empowered to author their own image of a flourishing future. These student-teacher relationships were built as they collectively and individually spent time with the ocean (swimming, paddle boarding, snorkeling, beach strolls, marine debris pickups, creating ocean inspired art, holding their breath, playing at being dolphins, etc.). In the case of Amaya, this teacher-student relationship is quite transparent. She grew to know the ocean as a source of unbound knowledge and ecological futurity that actively refused violent colonization—she had learned that "catastrophe can be our teacher, but it need not be the only one" (Frid, 2020, p. 148). Amaya also described how despite her teacher's scars from humanity, the ocean graciously became her sanctuary—a form of mercy and relationality she now strives to embody for others. This time together was essential before either student or teacher could share their visions of ecological hope.

Many human teachers never earn trust from their students. Very few know how to share personal pains or joys in generative ways. And most never inspire authentic ecological hope because, at best, they default to forcing their own dreams of the future upon their students. Imagine if all teachers of the Anthropocene showed-up for their students as the ocean did? What would this look, sound, and feel like? Perhaps, it this authoring of teaching that is the real work of educators moving forward.

Implications

Many science educators and environmentalists are desperate to understand how to support youth, and adults, in engaging in issues of environmental injustice without provoking apathy or ecogrief (Verlie et al., 2021; Pihkala, 2020; Ballard, Dixon & Harris, 2017). The lessons from the girls of the boat add several important contributions to the field regarding how youth respond to learning about these injustices. Although this study is situated within the context of an informal program near/on/in the ocean, these lessons of identity expression and formation, care for the marine world, worlding and teaching about/in the Anthropocene apply to most opportunities to learn about issues of environmental consequentiality, including other forms of pollution and even climate change.

The findings suggest that most youth, and adults, function from an expansive and diverse place (like the Pelagic Zone) that is saturated with a variety of ecoemotions. The cases also argue that ecogrief and ecological hope are not dichotomous as previously understood, but rather

differing eco-emotions shaped by our past and future identities. Ecogrief and ecological hope are often present simultaneously and work in tandem to author worlds beyond the Anthropocene. Together they challenge the conception that ecogrief is something to simply move beyond. And that different from grief, hope isn't something people are struck with—it is something a person creates by extending, redrafting, or reimagining the lost of parts of their identities.

Other important learnings shared in this paper demand that students be recognized as more than powerless victims of marine violence. They have sophisticated ways of metabolizing ecogrief and intentionally authoring new futures, that pull on critiques of this world, centering our intergenerational and multispecies relatives, developing new skills and knowledge, and knowing landwaterstarsair (Sanchez, 2022) as teacher. To catalyze the authoring of new worlds, educators need to encourage youth to harness these ways of worlding.

However, these brilliant moves towards ecological hope and worlding are often overlooked or dismissed as insignificant paths forward by the science and engineering communities. Worlding and other speculative forms of authoring against the Anthropocene remain corralled to the periphery of science education by capitalist and colonial attempts to maintain the status quo. There persists a lack of acknowledging the power and place worlding and authoring have in refusing the brokenness of this world. We must collectively empower this act as an intelligent and wise STEM practice—dreaming of an otherwise, no matter how distant or emotionally charged, doesn't belong to the humanities. These seemingly cerebral, emotional, and fictitious practices have concrete impacts. Afterall, everything must first be imagined.

Relatedly, Idra reminds us that educators should pause when passing judgment on students who display resistant or negative behaviors in relation to environmental issues. Our scientific work must embrace "felt knowledge" and dismantle the manipulative standards of emotional stoicism (Million, 2009; Wölfle Hazard, 2022; Rodriguez, 2022). Even rightful anger in youth is valid considering their threatened identities and the ecological burden they have inherited. In hindsight, it was unreasonable to expect each girl to be "happy", "fine" or even just "go-with-the-flow", especially considering the content of the project. So, I reiterate my earlier point, that contrary to what scientists at the station said and many educators imply, youth need no "fixing"—they are busy surviving others' ecological transgressions and refusing anthropogenic incarceration by authoring futures worthy of living.

These findings also suggest that youth understand the ocean as wise and dependable teachers. Which should make us wonder, how can human teachers shift our practice in reverence of our landswaterstarsairs (Sanchez, 2022) educators? And how can human teachers facilitate guest lectures or lessons by these beings? Are there ways to do this in formal classroom spaces or is proximity necessary, and therefore leaving the school boundaries a border to keep us in this world itself? What else facilitates this type of powerful learning and care?

Moving forward there needs to be more research to illuminate how specific teaching practices influence students' ability and ways of authoring ecological hope. What learning opportunities can we design to facilitate speculations situated in ecological hope? We also need longitudinal studies that explore how ecological hope is sustained among youth learning about, and being impacted by, environmental injustices. And more challenging, we need to understand how students process learning about the Anthropocene beyond the eyes of worried adults.

Notice that this call for future work is focused on understanding, cultivating, and sustaining ecological hope, rather than the foregrounding grief. This is intentional not only because grief has received a disproportionate amount of attention but also, so we take care not to rush into spaces to study ecogrief—which can taint experiences, perpetuate trauma, or invisiblize ways students are already authoring authentic and fabulous forms of ecological hope. It is time, not to ignore our collective scars, but to make a more concerted effort at realizing ecological hope and futurities for all youth. As we tread through these precarious times, we must ask ourselves:

How can we listen
Across species, across extinction, across harm?
I can only guess, but others know.

The whispers of the ocean are louder underwater
They take all the pain away
And sing songs of renewed hope.

This is why water gets stuck in our ears
It is little pieces of the ocean

Coming with us to repeat their songs
And not leave us alone.

May we together be on the lookout
For what world will next
Walk out of the ocean.

[This "found poem" is a mash-up of Alexis Pauline Gumbs' book *Undrowned*, Amaya's interview quotes and my personal journal entries from the field].

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SECTION 2

Socio-ecological Minding:

Examining Methodological Conundrums & Neglected Narratives of Inquiry with Youth

"There are poisons we cannot just do away with as if they had never been" (Haraway, 1994).

"Research is sometimes shit. It really does nothing for the world and works against conservation." (Romina during methods conversation, June 2021)

Conducting transnational scientific research alongside teen leaders for the sake of clean waters, preserving marine food chains, protecting endangered species and the futurity of Earth should elicit all the good feelings, right? And it did, in most ways. The Plastics Project, a youth-led marine pollution study, was born from an outdoor environmental education program hosted by a field station along the Baja Peninsula in Mexico. After several weeks of lessons focused on pollution, consumption and plastics, a central group of 13 youth committed to studying local plastic pollution and sharing their learnings with the community. Over time the youth's roles grew as participatory field researchers collecting samples to contribute to the Big Microplastic Survey, cleaning up local beaches, and co-designing new survey protocols to explore their wonderings. Students also helped design and build research equipment from upcycled materials and guided adult visitors through learning about and contributing data to the Plastics Project. (Learn more about this project through our Story Map: *Centering Baja Youth's Ocean Plastic Wonderings & Expertise*.)

Undoubtedly the Plastics Project seeded an abundance of good. It helped mend some broken relationships, became a site of belonging, motivated career changes, and significantly reduced plastic pollution in the region. The project also won funding to continue the work as a community and youth lab from 2022-2024. And it hopefully inspired lasting socio-ecological care (Haraway, 2016; Puig de la Bellacasa, 2017; Learning in Places, 2020) in the youth researchers and adult learners. However, the youth's Plastics Project also spawned unintended consequences. We knowingly and unknowingly made ethical concessions in the name of elevating youth expertise, pursuing "progress" as defined by dominant science narratives

(Harding, 2008; Stengers, 2017; Liboiron, 2021) and perpetuated other settler logics of doing science (Dietrich, 2016; Medin & Bang, 2014; Wölfle Hazard, 2022; Cajete, 2000).

So in many respects, this paper is my first exhale at the water's surface—an honest opportunity to process the consequential conundrums and neglected narratives that I had a hand in creating, or perpetuating, as a critical participatory ethnographer (Trueba, 1999; Madison, 2020). Approaching this work through this methodology, allowed me to stay with the beauty and entanglements (Haraway, 2016) that arose during the development and enactment of the Plastics Project. And as Angela Calabrese Barton and Edna Tan explain, critical participatory ethnographies give space to examine outside the binary of good versus bad and to complicate "toils and fruits of research" (2010, p. 196). By nature, this approach queers the research and moves it beyond settler and dominant paradigms of science (Wölfle Hazard, 2022) to expose consequential failures and shortcomings with how science is frequently enacted and taken up. Consequently, what is more fitting for a critical participatory ethnography but to reflexively critique the methods implemented and accept these critiques as gifts that can help (re)orient us toward just futures.

In this paper I suggest that this practice of reflexivity apply to field inquiries as an approach to growing students' responsibility, relationality, and care toward their human and more-than-human communities. However, this requires science educators and research partners to intentionally design learning opportunities to incorporate moments of what I call "*socio-ecological minding*"—or pauses to critically narrate science learning and research. Understandably the suggestion to incorporate moments of socio-ecological minding may be overwhelming considering the demands already placed on science educators. Nonetheless, slowing science (Stenger, 2017) to prioritize reflexivity is necessary for bringing witness to human and ecological entanglements and shortcomings within research (Kohn, 2013; Wölfle Hazard, 2022).

Although the context of this study is very specific, many of the tenants of this paper apply to most community-based conservation projects and even the work of more traditional and seasoned field researchers–who can be blind to the neglected narratives dominating their own projects (Wölfle Hazard, 2022; Liboiron, 2021; Whyte, Brewer & Johnson, 2015). Through this work, I hope to humbly expand how educators and researchers think about developing and sustaining socio-ecological care in students. Percolating through this foregrounded argument are

other central ideas including: (1) science as an art of ongoing revision through critical narration, (2) this ongoing revision and reflexivity disrupts colonial conceptions of science's fixed temporality, (3) critical narrations are gifts for the future, not just the reproduction of damaged-centered narratives (Tuck, 2009), and (4) youth can drawing on multilogics (Canipe & Tolbert, 2016; Higgins & Tolbert, 2018) to theorize and critically narrative scientific work in important ways.

As this is an article about slowing down to mind how we do science and whom this work is done by/with/for, it is only appropriate to pause in acknowledgement of those already discussing entanglements within their research and vulnerably offering public critiques of their own protocols. Just a few who are engaged in this type of reflexivity and moved us out of complacency work at/with CLEAR, (re)storying fish, Learning in Places, and FRESH Water Relations Lab. So, I pause to say to you, and others doing this work:

> *Thank you for wading in the muck to disrupt and desettle how dominant science is conducted. You complicated this project in important ways that none of us expected and made it impossible to live with the neglected narratives entangled in our own project. Lots of love and appreciation for opening our eyes!*

Literature Review

As said above, in this paper I argue for a new science practice called "*socio-ecological minding*" that builds upon the strengths and critiques of socio-ecological care (Learning in Places, 2020; Haraway, 2016; Puig de la Bellacasa, 2017). Socio-ecological minding prompts youth and researchers to pause and analyze problems or shortcomings of their scientific work through a critical lens informed by ontologies that disrupt harmful narratives, practices and paradigms of dominant science endeavors (Haraway, 2016; Bang, Brown, Calabrese Barton, Rosebery & Warren, 2017; Whyte, Brewer & Johnson, 2015).

In the conceptual framework, I detail how these concepts relate, but first I use this literature review to do three main things. The first subsection includes a review of why engaging youth in environmental inquiry is vital. Then, I elevate the importance of naming ways these inquiries cause unintended harm while offering a critique of socio-ecological care that helps illustrate affordances of, and the need for, socio-ecological minding. The literature review concludes with an argument for weaving multiple methodologies and ontologies together to

create a lens for recognizing the complex entanglements that pepper scientific work and learning and being in this world (Higgins, Mahy, Aghasaleh & Enderle, 2019; Wallace, Bazzul, Tolbert & Higgins, 2022; Kayumova et al., 2019; Learning in Places, 2021; Wölfle Hazard, 2022).

Why Engage Youth in Environmental Inquiries?

Most scholars now agree that the primary goal of science education is to engage students in the practices of science and engineering situated in real-world contexts and problems (NRC, 2013) to prepare youth to think critically and creatively about societal issues (Emden, 2021; Zidney, Sjostrom & Eilks, 2020; Bang et al., 2017; Morales-Doyle, 2017). One way to do this is through environmental inquiries. Throughout this paper I use the terms environmental inquiry/research, field inquiry/work/research, and even in-school/laboratory experiments to mean anytime that students are engaged in investigating real questions and problems with the aim to contribute to formalized science knowledge and/or create change beyond the education setting.

In their most generative forms, field inquiries are an opportunity for researchers to connect with local places, cultures, and communities while developing understanding for a specific ongoing matter of concern (Wölfle Hazard, 2022; Liboiron, 2020). Knowing this, some environmental education projects have created powerful opportunities for students to identify local issues, design ways to study the problem and disseminate learnings to other community members (Birmingham et al., 2017; Morales-Doyle, 2017). Youth involved in authentic environmental research often express an increased interest in science as it relates to society, improve scientific skills, and focus on designing systems and solutions that attend to the multidimensional needs of their community (Birmingham et al., 2017; Morales-Doyle, 2017; Morales-Doyle & Frausto, 2021). Additionally, when students from communities who have been marginalized from dominant science participate in these types of field inquiries, the image of who does science, where, and why is powerfully disrupted and reshaped (Wölfle Hazard, 2022; Calabrese Barton & Tan, 2020). Which expands how the world is understood and the future gains novel and important possibilities.

Despite this potential for transformation, most fieldwork with youth lack opportunities to support students in developing their awareness, or critical consciousness (Freire, 1970), of important societal and environmental issues. Field research with youth is often myopic. Protocols rarely translate from one project, community (human and beyond), place, culture, or structure to

another–meaning that student learning is unproductively narrow. Furthermore, these potentially transformative engagements are often hurried, often producing more environmental and/or societal harm (Kayumova et al., 2018; Stengers, 2017; Higgins et al., 2019). Unfortunately, these limitations stifle how those engaged can understand the environmental problem and design responses for profound justice (Medin & Bang, 2014; Harding, 2008). And Even when environmental inquiries are designed slowly with more attention to context, the focus frequently is about making sense of new data–including assessing its reliability and the procedures which determine data dependability (Windschitl, 2017).

In this article I aim to attend to these shortcomings of field work by expanding upon the works of Gloria Snively and Wanosts'a7 Lorna Williams, who work to weave Indigenous Knowledges into science teacher education and recommend that student research should undergo rigorous evaluation, not of intent but, of personal or group impact (Snively & Williams, 2016). Although focusing on the impacts of *doing* and other hands-on components of science have been critiqued in the past, this *doing* (which includes permit getting, protocol development, data collection, analysis, clean-up and reporting out) represents most of the time spent engaging as scientists and is the embodiment of criticality and theory (Longino, 1987; Stengers, 2017; Liboiron, 2021; Wölfle Hazard, 2022). Recognizing this and how care is seeded in the smallest things (Puig de la Bellacasa, 2017), other science education scholars have named the urgency in examining ethical considerations of how inquiries unfold and could be improved in projects (Zidney et al., 2020; Emden, 2021). This is because field inquiries are often stages for harmful entanglements (Haraway, 2016) that perpetuate violent settler logics (Dietrich, 2016; Cajete, 2000), rather than radical forms of care—Research is never the objective machine science or society would have us believe it is. However, neglecting to critique lab and field inquiries reifies harmful extractive power structures and practices between researchers, communities, other species, and "landairwaterstars" (Sanchez, 2023). Therefore, doing research should not be just another opportunity for youth to learn about a problem or even contribute data as scientists to a narrow topic. It can, and should, be more.

"Slippages" Between Intent and Impact

Field work is abundant with protocols, ways of knowing, and relationships that produce unintended consequences, or "slippages" which misalign our impacts and intentions (Laymon,

2020). Being a human living in this complex world means constantly failing to uphold our principles or values (Dilts, 2017). It is important to recognize these slippages and identify these failures because this helps (re)orient us towards better worlds (Laymon, 2020; Dilts, 2017; de Beauvoir, 1947) and ways of being that better attend to our collective flourishing (Haraway, 2016). However, these webs of entangled slippages are easy to overlook and environmental inquiries have frequently gone uninterrogated (Haraway, 2016; Puig de la Bellacasa, 2017)– especially when the doing of science involves youth.

Critical Pauses of Socio-ecological Minding

In several of his books, Paulo Freire outlined a theory of "critical consciousness" (or concientização) that could be applied across the disciplines to help expose social and political contradictions as means to act against, or transform, the oppressive elements of power and systems (1970). He proposed that personal and collective consciousness could be developed by pausing to ask critical questions and examine happenings in/of the world. These pauses towards critical consciousness, relate to what Maria Puig de la Bellacasa calls "matters of consequential care" (2017) and challenge environmental inquiries to disrupt normalized practices of violence and oppression.

While it is impossible to account and care for/about/with everything, pausing frequently to question and narrate how learning or research is unfolding aids students and communities in (re)membering the complexity, beauty, resilience, and power of the world. These caring and critical narratives sit in antitheses of "master narratives" which are stories, ideas, or approaches that "legitimize systems of oppression and power" (Crowley & King, 2018, p.15). As an example, one master narrative asserts that research must be proven statistically significant to be a valid and compelling source of knowledge, which invisiblizes the legitimacy of epistemologies outside of western dominant science. Unlike these master narratives, caring narrations can create powerful alternatives to socio-ecological problems.

The term "socio-ecological" pulls on a dense body of literature that acknowledges the intersection and relationship between society, ecosystems and more-than-human beings (Abram, 1996)--a relationship largely shaped by ongoing colonization and its undoing, throughout history and time across varying scales. Many science educators are grounding their work in the construct of "socio-ecological care" as a way of attending to students' futures being inextricably connected

to ecosystems (Haraway, 2016; Wallace, Bazzul, Tolbert & Higgins, 2022). Taking up socio-ecological care can help tether STEM sensemaking to societal and individual responsibility and obligation to the Earth and its more-than-human beings. However, most science educators were taught in ways that extract from consequential realities and relations to maintain the Anthropocentric, capitalist status quo (Bang et al., 2017; Kayumova et al., 2018).

Furthermore, without any clear measure of care, the construct of socio-ecological care often fails to hold individuals, or groups, accountable for their actions. When care isn't understood as a non-negotiable obligation, or "an action, never simply feeling" (bell hooks, n.d.), it becomes just another "thought habit" (Latour, 2004). An extension of this reasoning is commonly expressed as "we can't hurt what we love [or care about]"--which convolutes developing students' interest, knowledge, and love of ecosystems for cultivating actions based on relationships and obligations that come with these. Also, care can be uttered as apathetic platitudes, unjustly and selfishly assigning value of what/who matters (Dave, 2015), or worse, entangled in relational trauma.

Socio-ecological minding calls into question this assumption about socio-ecological care and attends to the brutal reality that we frequently slip, or fail, in caring for ecosystems because we don't know *how* to care for places or beings well, even if we love them. Socio-ecological minding is designed to explicitly acknowledge that "slippages" are an inevitable result of colonialism and capitalism erasing ways of knowing and being from dominant science.

"Minding" remains largely on the periphery of education and environmental literature with the exception of scholars Morwenna Griffiths and Rosa Murray (2017), who prompt us to consider the multifaceted ways "minding" may unfold and the implications this might have on human actions. For example, "to mind" is a call to show up in this world differently. "Mind your step." "Mind your manners." "Put your whole mind into it." "Connect your mind with your heart." "Oh, sorry, that slipped my mind." These common phrases remind me of my grandmother–and while they could be read reductively, edging toward nagging, they are said not to belabor damage narratives, but to think, feel, and act in ways that realize futures worth desiring (Tuck, 2009). A mindset (pun intended) that we need to grow in students, science teachers, field researchers, and each of us. And unlike care, which implies a fixed end-point to strive for, minding is a present-continuous verb, without start or end and by nature asks us to consider the future in our critiques of the past and present.

Minding can be radical–grasping ideas and ways of doing science and shaking them to their roots (Davis, 2006), so they may be transplanted to more fertile grounds–grounds outside of colonized dominant science, capitalism, and extractive relations between humans and ecosystems. When constructed critically, minding is to think intergenerationally, watch over, emotionally connect with, think deeply about in community, and to get mentally/emotionally swept away but still keep-in check our ways of being. At its foundation, minding embraces ongoing revision and reflection, accepting critique and reflexivity as future-oriented gifts in a world ruled by white settler logics of perfectionism, defensiveness, and comfort. In imagining socio-ecological minding, I challenge us to revisit the relations and obligations that have inspired, sustained, tested, and fallen apart amid field inquiries.

Multilogics Can Inform our Pauses

Mark Higgins, Sarah Tolbert and Martha Canipe, who also explore and critique socio-ecological caring, suggest taking a multilogics approach to critiquing learning opportunities. Multilogics pulls together varied epistemologies and theories to make sense of the world around us (Canipe & Tolbert, 2016; Higgins & Tolbert, 2018). Being open to varied perspectives and ways of understanding the world is essential for disrupting the racist, anthropocentric western science agenda (Brayboy & Maughan, 2009). Pauses informed by critical multiplicitous ideas are essential as they create "new and differing pathways into reconfiguring the ability to respond, (re)opening the norms and practices of response-ability by disrupting, displacing and dislodging taken-for-granted assumptions that linger and lurk with science education" (Higgins & Tolbert, 2018, p. 277).

Braiding these varied ontologies together attends to their differing histories and implications, inherently honoring that no single perspective/theory can realize justice without oversimplification or erasure (Higgins, Mahy, Aghasaleh & Enderle, 2019; Wallace, Bazzul, Tolbert & Higgins, 2022). Taking up critique informed by multilogics is necessary trouble for casting light upon the inequities and violences that run rampant, yet too often neglected, throughout science education. Centering how science unfolds through a lens of ethics is very different from fieldwork designed upon the narrow constructs of settler logics that are prevalent in dominant science (Dietrich, 2016; Liboiron, 2021; Whyte, 2018; Wölfle Hazard, 2022) .

Looking across the literature of Indigenous Science, Science Technology and Society, Intersectional Environmentalism, Latina Feminism, Anti-racist and Feminist-Queer theories there are some common concerns that function as entry points into seeing, critiquing and designing beyond the slippages that occur during environmental research. Although these concerns vary between theoretical frameworks and how individual authors take up these ideas, what is important in implementing a multilogics approach in K-12 science education is not specific definitions but attending to these shared themes to grow students' awareness of other ways of thinking and being. These prominent concerns/ideas include but are not limited to: researcher (youth or adults) positionality and power, protocol designs, stakeholder voice, ways of relating, material use, stewardship, and responsibility toward humans, more-than-humans and landairwaterstars.

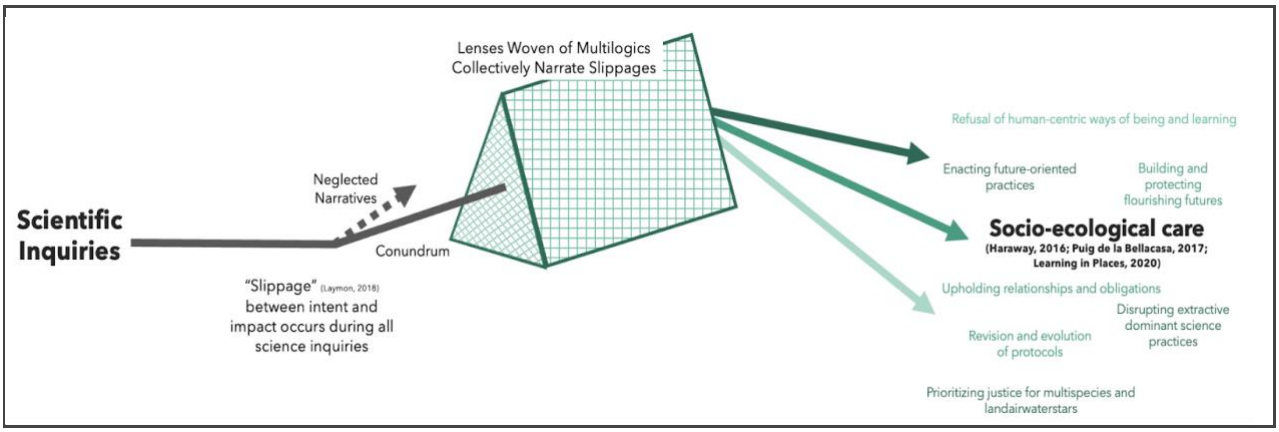
Cumulatively, this research points to the importance of socio-ecological minding as a practice of narrating what happens during inquiries to push against master narratives (Crowley & King, 2018). And, as seen by the absence of empirical research on these ideas throughout this literature review, this study is needed to illuminate how critical narration can unfold within the context of youth environmental inquiries.

Conceptual Framework: Introducing Socio-ecological Minding

Practicing socio-ecological minding is an invitation to slow down to shine light upon, and discuss, the slippages that occur during, and because of, scientific inquiries. As shown in Figure 1, understanding critiques beyond dominant science narratives is challenging as it requires teachers and students to apply lenses woven of multiple critical theories/logics to narrate different slippages. Some slippages are brought into the light by students themselves as conundrums they are working through. These conundrums go through this dense medium woven with other worlds and perspectives they are drawing upon to theorize and complicate the doing of science. However, most slippages remain neglected narratives that stay in the periphery untheorized or critiqued by youth. These neglected narratives are not only unable to foster socio-ecological care but often reify harm and violence inflicted by dominant science (Liboiron, 2021)—they continue along the trajectory inflicted by the slippage, far from restorative forms of socio-ecological care. Therefore, the practice of socio-ecological minding is not about critique, it is about identifying ways of doing better that set a new, more just, course for science.

Figure 1.

Socio-ecological minding narrates conundrums to transmit socio-ecological care



With time and repetition, socio-ecological minding as a form of critically narrating science learnings and research can hold individuals and groups accountable for their actions, without becoming another "thought habit" (Latour, 2004). And this practice will require science educators and youth to do science differently, despite forever being in the "perpetual stickiness" of fieldwork, with no pure or simple ways forward (Akomolafe, 2020). As Karen Barad writes in *Meeting the Universe Halfway:*

> It is not possible to extricate oneself from ethical concerns and correctly discern what science tells us about the world. Realism, then, is not about representations of an independent reality but about the real consequences, interventions, creative possibilities, and responsibilities of intra-acting within and as part of the world (2007, p. 277).

So, the question becomes: how can environmental inquiries become critically narrated (Freire, 1970) in ways that are expansive, but also elicit better actions for the world and beings in it?

"AGUA MALA!":

Historicizing the Origins of Socio-ecological Minding

Below I describe a pivotal event from the field that catalyzed my thinking about socio-ecological minding. This moment brought into clarity, along with what I had been reading at the time (*Pollution is Colonialism* and *Matters of Care)*, the parallels between my son (the canary in

a coal mine), the panicked contortion of Tapia trying to move toward safety, and my painful (re)alization that conservation work often has unanticipated and harmful consequences, no matter our intentions. I share this story knowing that the moments that allow us to see things impact what is seen and understood–just as a researcher's identity matters, so do the origins of our questions.

> *Fieldwork in the heat of a Mexican summer is physically taxing and because we were studying a matter of consequential concern (Puig de Bellacasa, 2017) there was often a heaviness pressing upon our hearts and minds. So, in early August we went out with the youth researchers for a boat trip. We were celebrating ourselves and making a big deal of refusing the work—embracing rest and play as everyone needed to recharge before the next big data collection and teaching cycle. Jumping in at the first snorkel site (selected by a few youth) the water edged on frigid but was intoxicatingly clear and a large bait ball of silver fish danced around us. The site was idyllic and Nico, my 16-month-old, who had become a team mascot of sorts, was happily being towed about when he started to scream inconsolably. Frantically we pulled him out of the water, but his cries didn't stop. Feeling a bit itchy myself, I stripped him out of his life vest and wetsuit to rinse him with water from my canteen. His cries stopped abruptly. Okay, he had detected something in the water but no one else seemed bothered and there was nothing to see. So, I stayed quiet not wanting to ruin the calm that had been restored.*
>
> *But within minutes everyone was in a panic. Tapía sprinted back to the boat yelling "AGUA MALA! AGUA MALA!". His whole body contorting as his arms propelled himself quickly through water while slapping at his body with every stroke. Behind him the group followed, desperate not to be neck deep in something they hadn't seen. Something they hadn't expected. Something that was warping this restorative moment into a nightmare.*
>
> *While pouring drinking water over the skin soothed the stings and the group moved locations, a string of problematic, or failed, "sustainability projects" or "restoration sites" I had visited over the years bubbled to the*

corners of my mind. Had our fieldwork unintentionally brewed "agua mala"?

What unseen stings had the Plastics Projects delivered?

"Agua Mala" was a term used in the community, and across other parts of Mexico, to describe currents, or pockets of water, with "sea lice", microscopic jellyfish, or other transparent plankton that sting. These stings, while mostly temporary, can be incredibly painful and leave visible bites. In the bay, these pockets of "agua mala" can move quickly into an area, unbeknownst to swimmers. In hindsight, it is almost as if the water and bay were claiming a voice at the research table. The ocean seemed to be making a poignant statement and asking us to consider all our actions and obligations as a team—probably not to stop our work, because that day the ocean also rewarded us abundantly for passing time with it, but just to pause and mind our doings. So I was left wondering in what ways did we do and perpetuate traditional cycles of harm through the Plastics Project and how might socio-ecological minding have helped attend to this?

More on Methods

As mentioned above, sharing the conundrums and neglected narratives of the Plastics Project was not the original intent of this study, but rather an imperative move towards reflexivity (Latour, 2004) that had been missing. Therefore, these methods were designed retrospectively pulling upon interview data with youth and collaborating scientists or community members, field logs, photos, my personal research journal, and other field artifacts.

Knowing how settler logics are designed to partition researchers from our obligations and intentions (Harding, 2008; Haraway, 1994; Wölfle Hazard, 2022), under the false guise of objectivity, I instead tried to design my methods for accountability. Because of *how* this analysis was conducted, who it was informed by, and what was required to see and reason with the conundrums and neglected narratives, I leaned most heavily on Latina Anti-colonial frameworks (Zuñiga-Ruiz & Gutiérrez, 2022) and Feminist Anti-colonial standpoints (Harding, 2008; Liboiron, 2021). Both stances study research, rather than a problem, and embrace tensions within the work itself. For example, Helen Longino, is interested in "doing science ethically with care" and the results matter less than the process—"we focus on science as practice rather than content, as a process rather than product, hence, not on feminist science, but on doing sciences as a feminist" (1987).

To this point on reflexivity, it is essential that I acknowledge my own identity and positionality as a researcher… I came to this work as a visiting white settler to Cochimí lands, known presently as the Baja Peninsula of Mexico, hoping to understand how local youth can disrupt patterns of extractive science and reductive narratives about what they are capable of as they learn to study the ocean. While I intended to take a backseat, this didn't happen. Staff shortages, Covid constraints, and my own identity as a white science teacher from the United States conducting dissertation research, quickly positioned me as an expert and a project leader–despite my resistance and true co-learner status within the project. But once in, I was all in. In many ways I became the primary facilitator of the intensive summer inquiry work–not an outsider passing judgment upon others (Banks, 1998), but a complicit participant, designer, and facilitator of the fieldwork conducted with the youth researchers. It was on me to find ways to center youths' ideas and for our work to be deemed "meaningful science". However, in many other ways I had no power (I couldn't get permits, select survey sites, change the program flow/schedule, modify cycles of data collection, change dates and times students were welcome at the field station, etc.). Even so, I constantly tried to recenter the project on students' questions, observations, and interests that drove the work. (See Appendix A for a list of major research activities and milestones that occurred during this study that were primarily driven by students' curiosity and design.)

Data Analysis Through Socio-ecological Minding

Knowing how easy it is to slip (Laymon, 2020), or stray from "the trouble" (Haraway, 2016), I designed the data analysis process with a multilogics approach. Before analyzing data I leaned into diverse theories and ontologies by asking, and reasking, myself the following four questions:

1. What relations and obligations do we need to recognize and care about?
2. What other perspectives, including multispecies and other-than-being beings, should be considered?
3. What has been overlooked and how are we attending to these "neglected relations and ways of being?
4. How are our actions refusals of harm and violence historically cast by dominant science?

There are no simple answers to these questions, if asked openly. Which means that answers can morph with complexity. Because of this I share my early abbreviated answers to these questions in Appendix D to help make transparent the multilogics that informed this analysis from the beginning. Centering these questions helped weave, and reinforce, a critical lens of multilogics that I revisited and mended as needed throughout the analysis process.

The four questions guided the open coding process (Strauss and Corbin, 1998) and helped capture my critical interpretations (Roseberry, Warren & Tucker-Raymond, 2016). By starting with field notes, I was able to identify major shortcomings/tensions related to these questions. Next, as documented in Table 1 and 2, I looked across these shortcomings/tensions to identify overarching themes. Then, data sources containing these salient themes were counted as one entry, with two exceptions–photographs and interview transcripts. Photographs containing the same content were bundled together as one entry. On the other hand, unprompted interview segments that retold or alluded to the same topic/story were counted as separate entries to ensure the significance of the subject wasn't underrepresented. Furthermore, I attempted to honor that silences on topics/stories can also carry significance, often indicating harm or doubt, by pulling heavily on my own field logs and even personal journal entries which were places intended for my own cataloging of tensions and reflexivity (Madison, 2020; Wölfle Hazard, 2022).

Through iterative analyses it became apparent that some themes were troubled (discussed and reflected upon) among the group of youth, albeit briefly—these narrated stories, however short, I categorized as "*conundrums*". While "*neglected narratives*" were never formally discussed with youth, it is the adult educators who apply a lens of multilogics to critically narrate and theorize about what is happening. Conundrums and neglected narratives are both unintended byproducts of scientific work that when storied aren't about damages, but these narratives become a space for future repair and thriving.

Table 1.

Codebook: Overarching Themes with Definitions

Overarching Theme	**Definition**	**Key Indicators**
Contributes to Plastic Consumption or Pollution	Contributing to local and global plastic waste and pollution before and during the implementation of our research project—this includes both formal and informal activities/events/happenings.	Plastic, garbage, dump, garbage can, ecoladrillos, litter
Desettling Dominant Inquiry Methods	The methodological approaches and theories guiding how fieldwork transpires. Considers the paradigms undergirding how fieldwork and learning from these inquiries.	methods, protocol, consent, equipment, age, voice, type/forms of knowledge, whose knowledge
Community Relations & Obligations	The construction of relationships in/between/through our project and the messiness of having multiple relationships to attend to. These relationships may include any combination of adults, youth, community members, marine or land species and other-than-being-beings. Noting how futurity and well-being is or is not attended to.	connection to family/friends, responsibility, rules, promise, survival, how to act, expectations, pressure, bravery, disagreements, shame, job/career, future
Conundrums	Shortcomings, tensions, or dilemmas of consequentiality that are surfaced repeatedly among the team of youth researchers. Youth reason with slippages with little, to no prompting, by drawing from other worlds to construct their own lens of multilogics and theorize.	
Neglected Narratives	Shortcomings, tensions, or dilemmas of consequentiality that are discussed briefly, or not at all. Adult researchers and/or educators may reason with slippages independently from the youth, by drawing on formalized multilogics or these slippages may remain on the periphery unattended to.	

Table 2.

Frequency of Conundrums and Neglected Narratives Across Data Sources

Data Sources	Contributes to Plastic Consumption or Pollution	Desettling Dominant Inquiry Methods	Community Relations & Obligations
Field logs (n=56)	9	22	11
Personal research journal entries (n=33)	16	3	17
Interview data with youth, scientists & community members (n=39)	12	6	15
Photos (n=178)	26	40	43
Youth post fieldwork surveys/feedback (n=23)	5	4	5
Team planning or debrief artifacts (n=40)	4	1	8
Adult visitor/student artifacts (n=35)	4	16	8
TOTAL (n=404)	**76**	**92**	**107**

Overtime, I brought these examples of conundrums and neglected narratives to my colleague and co-facilitator Romina, and we discussed intent and waded through the dangerous territories of "what if we had…" or "we should have…". Audio recordings and critical ethnographic notes of these conversations were maintained so we could track how our critiques morphed with time and space from the project. The goal remained not to undermine the

brilliance of the work done by students or staff at the field station–but rather, reconcile ways the project could have improved given the research team's interests and obligations.

In the findings I present the most troubled conundrums and neglected narratives. However, (re)animating these stories is not enough—as argued in this paper, this *doing* should be read and interpreted critically to tangibly move us towards socio-ecological care. Therefore, in lieu of a formal discussion section, I slow (Stengers, 2017) after each conundrum, and neglected narrative, to dabble in socio-ecological minding myself. While my responses are undoubtedly different than what the youth would have said, or even other adult leaders, by queering these narratives myself, I experiment with what socio-ecological minding could entail and speculate about the transformation it may generate.

Examples of Socio-ecologically Minding Conundrums and Neglected Narratives

The findings knit together student dialogue, photos, personal journal entries, interview data, and other field artifacts to story one major conundrum and two significant neglected narratives. The conundrum, which was ubiquitously discussed by the youth researchers, troubled ways the project contributed to plastic consumption and pollution. Students briefly engaged with these concerns through socio-ecological minding by questioning intent versus impact within science research/experiments, narrating their work in terms of troublesome metaphors (ie., the "Multiplying Horcruxes" metaphor), adapting field protocols, and asking of themselves "what should be done now?". On the other hand, the two neglected narratives remained in the troublesome periphery and were alluded to only in private/individual moments or in informal spaces–leaving few opportunities for practicing socio-ecological minding as a collective. These neglected narratives fall into two categories (1) desettling dominant inquiry methods and (2) honoring community relations and obligations. As I reflexively played with socio-ecological minding these narratives, issues regarding how our research did/didn't consent nature, instigated ecological diasporas, attended to the communities human and more-than-human that we care about and love, or victimized nature surfaced.

Additionally, analysis revealed that the naming of conundrums and neglected narratives became more common in the last third of our time conducting fieldwork. This pattern was most evident among my own field logs and personal journals. Where a pivot occurred after the "Agua mala!" event and my critical readings (Freire, 1970) of what was transpiring in the field began to

dominate my entries. Although this trend may be indicative of the natural reflection that unfolds as research hits a dependable and more easily managed pattern, I also believe that these critical readings, or early forms of individual socio-ecological minding, had grown my own critical consciousness of field research. And as argued throughout this paper, pausing to practice socio-ecological minding, even if individually, makes conundrums and neglected narratives easier to identify, more difficult to live with complacently, and impossible not to shed light upon. Socio-ecological minding is like a muscle, becoming more precise and forceful with time and use.

Conundrum 1. Contributions to Plastic Consumption and Pollution

Despite our team's attempt to limit plastic use and generation and throughout our research, we contributed to the plastic pollution problem in significant ways. Although this conundrum surfaced fewer times across the data sources, it resonated with almost all the youth and adult researchers involved–surfacing in individual reflections, interview transcripts, or informal small group discussions. Furthermore, participants were engaging in brief socio-ecological minding related to this conundrum throughout all stages of the project: setup, fieldwork, and analysis.

Setup. Before June 2021, youth had collected few field samples (n=6) but as our team dreamed of accelerating the arduous data collection process and community impact, we scaled our equipment to advantageously leverage collection assistance from visiting scientists and students to the station. However, this meant that the team needed to prepare equipment so four groups, each facilitated by a set of youth scientists, could simultaneously collect and analyze samples.

Returning home with only a few weeks before moving temporarily to the station, I had been tasked with gathering materials for scaling up the project: rulers, hand lenses, tweezers, collection containers and a hanging digital scale—items we had not found at the station or in town. After visiting three different stores (a process of pollution in itself) and finding only plastic rulers, I purchased a "set of 12 wooden rulers" online from the same vendor selling the hanging digital scale and had them shipped together to reduce pollution from packaging. In hopes that they wouldn't snap in transport, I packed them down to the station without opening the small box. To our dismay the set of rulers was sealed in a large plastic bag, stuffed with bubble wrap and each ruler was then individually covered in plastic film.

Figure 2.

Collage of Plastic Trash Generated through Material Prep and Project Scaling

Although the team had set out to stock our lab in ecologically mindful ways, our awareness didn't prevent the ruler conundrum. Nor did it avoid the rulers from becoming a metaphor for how most of our new supplies found their way into our lives—wrapped, covered, and hidden beneath layers of unexpected, troubling plastic. As shown in Figure 2, prepping materials to expand the Plastics Project introduced large amounts of plastic into the community. So much so, that youths' comments about "everything is plastic" or "this also is in plastic" lost their edge, becoming background noise, and an anthem of resignation.

In the field. Using our equipment on remote beaches added challenges we had to learn to mind. The norm was for student groups to clean and inventory their equipment upon returning to the station, which was good in theory but made searching for missing materials that had been dropped or left, pieces we knew would be swept away at the next high tide, impossible. After several students reported losing plastic collection containers, the group tried to diligently inventory and track-down equipment before leaving sampling sites. But proximity to conundrums always work like gravity—lulling us into sleepy, mistake making. For example,

twice I dropped my beloved snorkel mask (which accompanied me everywhere) in the intertidal area over the edge of a boat. Luckily, several students found and retrieved it each time. This is all to say that we know things were left behind (equipment, personal belongings, etc.) even when the item was treasured and even after our attempts to be more attentive.

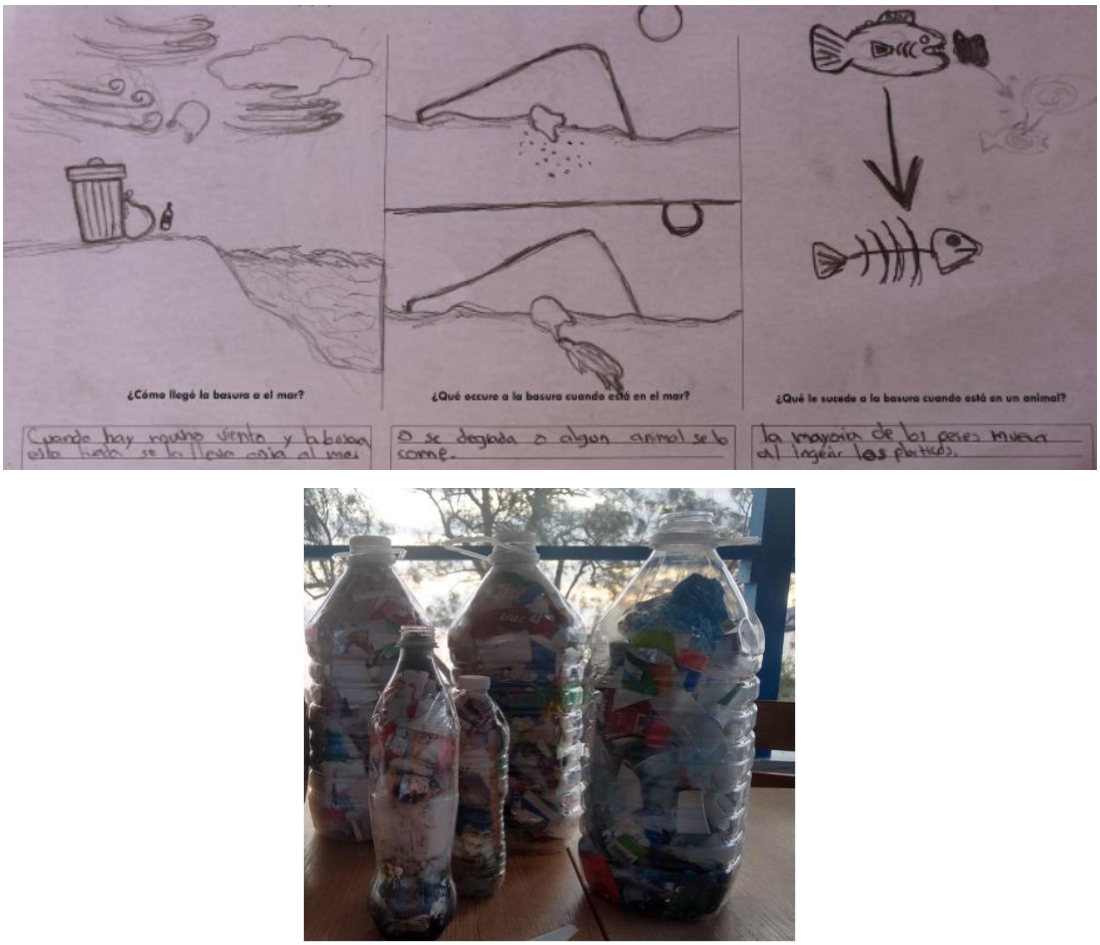
Another issue that arose in the field was that as we collected micro and mesoplastics from sun-penetrated wrack lines, the photodegradation process was often well-underway. A single bag or wrapper could disintegrate on touch. During a debrief session with youth and visiting adults this conundrum came into focus: “They are like that Horcrux cup in Harry Potter—the more you touch them, the more they multiply " another team member offered, “we need shovels to collect the plastic bags. We could dig around them and collect all the sand around it. [Otherwise] we’ll just keep making microplastics”. Although this conversation serves as a glimpse into what more intentional socio-ecological minding could facilitate, because it was so brief, the conundrum did not receive the attention it deserved and as a result, our doing in the field didn’t change. No shovels were brought, and we crafted many more plastic horcruxes through our work.

Post-collection and analysis. Conversations with youth, participating scientists, and community members frequently grappled with questions about: “What do we *do* with the plastics we collect?” With open undesignated dump sites around town, but no waste or recycling collection system, options were few. Some community leaders promoted burning trash, while others swore by burying it or transporting it out of town in their own vehicles. Although admittedly discouraged by this reality, the students didn’t shy away from narrating and troubling what professional scientists in the Global North had failed to consider or provide guidance around.

One youth summarized this concern well, “We need to take care of the plastics we collect because I worry, I really worry a lot, that it will--(hand flying off gesture)—go to the ocean. And now it will be here (points nearby) where we fish and swim”. As seen in the student sketch below, this tension of what to do with the plastics we collected was a dense conundrum that students frequently waded in. This was the issue that saturated many of the critical debriefs that did transpire among the entire research team. With time, our group decided to arduously add the plastics to ecoladrillos (2L or larger water bottles that once compacted with plastic could be used for construction projects) rather than add them to the pile designated for the dump because at the very least these “ecoladrillos would slow the return of the plastics to the ocean”.

Figure 3.

Student Modeling Wind Taking Trash to Ocean and Photo of Ecoladrillos Full of Plastics



Practicing Socio-ecological Minding. Reflecting on this conundrum, I realize (again) the brilliance of my youth research partners. They didn't shy from naming the failures of this project and while minding these slippages, they pulled on other theories and worlds without prompting. This reveals their readiness and natural inclination to engage in socio-ecological minding as a way not just to identify slippages but to also build a bridge from these learnings to new inquiry practices. Specifically, the multiplying horcruxes metaphor was a poignant opening for our team to acknowledge ways the intent of our fieldwork didn't align with impact, and then use socio-ecological minding to theorize and imagine new versions of data collection. The youth seemed to understand, without explanation, that socio-ecological minding isn't about self-shaming or flagellation but about ongoing revision to do better (Laymon, 2020) and that science research is never really "done".

While transformative, I do wish our group had deepened our discussions through practicing more intentional forms of socio-ecological minding as these conversations were never elevated beyond the Plastics Project–despite the true power of socio-ecological minding lying in looking across research, systems, places, and times to see the impact of science outside of the singular inquiry under narration. Considering this, we should have extended the ruler and multiplying horcruxes metaphors into discussions about the unintended consequences that always exist when doing fieldwork and harms that can never fully be avoided–because, after all, we live in a world with too many entanglements to fix things or fully restore them (Haraway, 2016). To support this next level of criticality, I should have asked better questions to help the group see (Freire, 1970) and critically unpack the *doing* of science both within the current project and more universally. For example, I could have asked:

- What can we learn from the ruler situation?
- How does the "Multiplying Horcrux" metaphor help us think about our intentions vs. impacts? Is this true of all field inquiries and, if so, should we stop our work?
- Why do we forget to be mindful? How can we be forgetful about things we deeply "care" about?
- What should we do now? How should our protocol change and why?

To be frank, these are the uncomfortable questions that could have helped disrupt the master narrative (Crowley & King, 2018) that scientists come with good intent and are positive "fixers" or "saviors", or at worst neutral, without fault or culpability (Haraway, 1996; Higgins & Tolbert, 2022; Stengers, 2017, Kohn, 2013).

Moreover, although socio-ecological minding doesn't always necessitate tangible change, within the context of this project if the third and fourth questions had been minded, these critiques could have offered the gift of protocol transformation. For example, we could have set a course for the forgotten ecoladrillos. But at the time, deviating from the predetermined inquiry methods to address the ecoladrillos, rulers, or multiplying horcruxes felt impossible given the tight research timeline. However, if we had engaged in more purposeful socio-ecological minding and slowed the progress narrative (Stengers, 2017), we could have collaboratively edited our field methods so these conversations were more than "thought habits" (Latour, 2004) but catalyzed inquiry improvements (Liboiron, 2021; Wölfle Hazard, 2022). For example, we could have visited thrift shops or received donations of previously used rulers, hand lenses,

tweezers, and even plastic buckets. This would have simultaneously attended to our project goals, the surfaced conundrum and given life to otherwise neglected items (Puig de la Bellacasa, 2017). Slowing would have also held space for the truth that protocol revisions can only solve so much, never completely unsnarling the mess (Liboiron, 2021)--Realizations that take time to grapple with and, when necessary, mourn. As in this case, slowing down can be a powerful antidote for troublesome inquiry practices (Stengers, 2017) because longer pauses to practice socio-ecological minding morph time towards environmental justice, rather than away.

Neglected Narrative 1. Community Relations & Obligation

Looking across the data it was apparent that one of the most neglected narratives were the tensions we encountered trying to attend to relationships and obligations within our own team, with people in town, and even the sea itself. Despite surfacing in 92 different data sources, across conversations between Romina and I, and some visiting scientists or educators, these stories were never narrated by youth—they remained toxicly unaddressed in the periphery. Additionally, the frequency in which this neglected narrative surfaced was surprising given that, like the first conundrum, we tried to design for rest, joy, and community by building in regular time for group games, meals together, "tiempo libre", surveys to collect feedback, and celebrations related to and adjacent the fieldwork. However, these proactive ways of being together didn't address the unexpected plot twists or tensions. Below, I share a few stories from the Plastics Project of failing to uphold our obligations to our communities and then practice socio-ecological minding to be (notice present tense) in better community.

"Next time" we will do community. Although this research was initially designed with love and care aimed to center youth and local community members, we sometimes failed to prioritize these obligations when *doing* inquiry—our other responsibilities became the easier default. For example, conducting fieldwork alongside visiting scientists and science educators studying at the field station created the challenge of matching their availability with low and high tide patterns, and almost always collecting samples during the heat of the day. Spending several hours out in 90°F or higher temperatures, was challenging and wore at the youth despite swim breaks, popsicles, water, and shade time. Lia, one of our most dedicated students, experienced heat exhaustion toward the beginning of July. After several brief comments her mind was made-up, and she flashed a single sad head shake and finger to the throat when dropped off at her

house in the evening. She was brilliant and her absence would be a blow to our team. But everyone, except Romina who was like family to her, eventually moved on. As someone not greatly affected by heat, I was surprised Lia didn't rejoin us for fieldwork and privately Romina and I pondered what we would do differently next time.

Another example unfolded after we unexpectedly sampled and collected 36k of marine debris from a beach. Knowing this beach sat within the project boundaries of a local marine protection organization, Romina reached out to see if the group wanted the collected trash for their own data on macroplastics—the hope was to build solidarity with the larger local Anti-Pollution community. With a plan to collaboratively sort the debris, we first visited their office to learn about their efforts and unique protocol, which logged each individual debris item into categories. The visit went well, and the adults were impressed with the youth's knowledge and commitment. Unfortunately, it turned out that none of the members from the group could come to the station that afternoon to assist with the sorting and documentation process. And, with a new group arriving at the field station the next day, sorting and cataloging had to happen "now" to ensure a clean station and that we were prepared for the next big sampling day. Hoping to build allyship we apprehensively agreed to enact their protocol ourselves and promised to return the completed data sheets.

As shown in Figure 4, most students jumped into the work and pushed beyond frustration that they didn't have much guidance or help. Some students pulled keepsakes out of the pile (a glitter plastic bow for their baby cousin, fishing rope for bracelets, an old lighter, etc.). However, the atmosphere would tense periodically with confusion about how to measure long knotted fish rope or line, count/estimate thousands of microplastic pieces or even categorize a piece of trash according to the different protocol. The protocol was tedious and time consuming, especially as our group tried to efficiently catalog over 36kg of trash—we were drifting in the "perpetual stickiness" (Akomolafe, 2020) of upholding our obligations.

Figure 4.

Youth Sorting Trash

As project leaders, we had wanted the youth to learn alongside community partners to expand their knowledge and build solidarity with others who also cared about this issue. Instead, the narrative became that "next time" we'd work with them. For now we should just hurry through the protocol and go to the beach party planned—we were desperate for joy and fun to reign again. But our promises of "next time" have yet to happen.

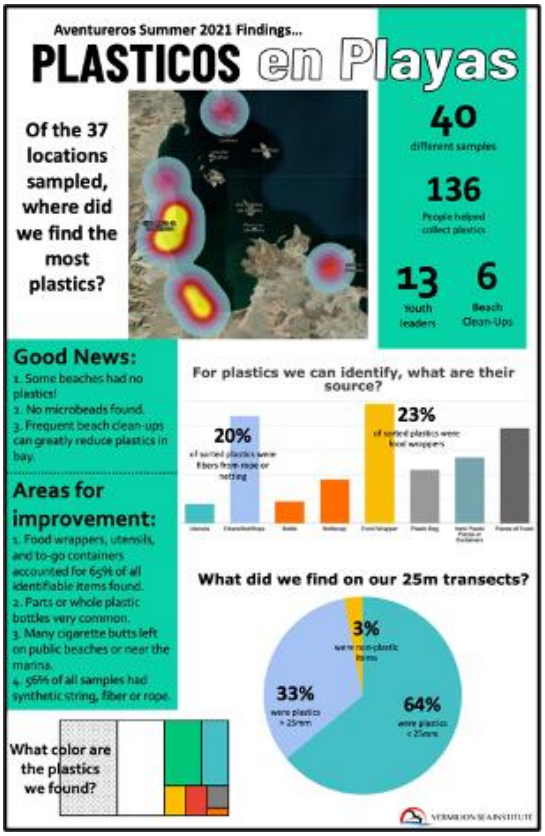
Forgetting to protect hopeful futures for all our relations. The second theme within this neglected narrative was the many times we failed to author a future worth protecting. For instance, when describing the project to others, students often referenced the endangered status of marine animals or the physical illness or death that can fall upon consumers of plastics and no one complicated this narration. For example, Daniela told visiting Master's students: "you come to see the whale sharks and turtles and other things, but they are decreasing and lots of us, me for example, have seen them with trash or all wrapped up in things. And we know they probably won't be here for our children". Her message was met with a quiet, worried depression. So, although the youth discussed more subtle problems created by marine debris among themselves,

it was these apocalyptic narratives that they relayed most frequently to outsiders. And in the perpetuation of this oversimplified understanding of nature, we neglected to see nature as resilient (Whyte, 2018) and focus on narratives less about mortality and more about flourishing futures (Haraway, 2016).

Forgetting to hope neglected our obligations to the youth involved but also to the local community and bay itself—however at the time, we didn't see this. Instead, the team considered how to use our data to inform the human community about the problem and state of nature, never pausing to ask: Would these sites want to be discussed as broken? Should this place be discussed without attention to hope? In another example of this, our community poster (Figure 5) mostly emphasized polluted beaches and how these sites had been violated. A small sidebar highlighted three pieces of "Good News", but the overarching message was clear: the bay had been violated and was a victim.

Figure 5.

Community Facing Poster



At the time no one associated with the project asked if this was an acceptable narrative about something we deeply cared about and wanted the best for. It was not until the early fall, that Eve Tuck's call to suspend damaged-centered research (2009) intersected with this work and I began minding these narratives and wrote:

> "What does mapping pollution do for a community? Is the narrative forwarded justice-oriented or reproducing harm? If the beaches and ocean itself were to recreate this poster how would it be different? This whole thing reminds me of the yacht parked in the center of the bay---does our poster convince people to care or that it is too late, so pollute without guilt? Do we cultivate local pride in the bay or focus too much on its destruction? How could we have also mapped hope and joy to encourage others to live in good relationships with the bay? Argh, I wish I could go back in time."

Blindsided by these tensions, I reached out to Romina several months after sampling had concluded, and we created a follow-up activity where students' collaboratively mapped spots of joy and hope along local beaches. Despite this effort, the conversation was superficial, as it was smashed between other activities that had already been planned and many youth were absent. The time for minding hopeful futures had lapsed within the Plastics Project.

Practicing Socio-ecological Minding. Unlike the first set, these stories about relationality and obligation remained neglected. This was a grave disservice as this work *always* transpired in relationship to the land, waters, each other, the local community, and even plastics (Liboiron, 2021). In particular, Lia's story, which is also the story of others who couldn't participate physically because of the heat or other corporeal needs, serves as a potent reminder that the web of relations we are bound up in also includes those within our own inquiry team. In ignoring these realities and the importance of our own immediate community, we perpetuated ableist standards and erased that this work is not about dying but about living—and living well together. Minding these relations should have been a priority as this is how we manifest flourishing futures (Haraway, 2016). After all, what is more important than reflecting upon what it means to live well amid the mess of our sometimes conflicting obligations?

If we now practice socio-ecological minding to collaboratively reflect upon how we honor our relations and uphold these obligations, we can ask:

- Who/what brings us to this research? How are we honoring these relationships through our research?
- How does our research connect with people, multispecies and places?
- Who are our communities? Are we having the impact on these communities that we should?
- How are you *feeling* about our fieldwork? Why? What could better support you in doing this work?
- What reasons do we have to be hopeful within our research? We can't just go forward without hope, so how could we seed more hope through our research? Should something change?

Without knowing how students might have responded, I anticipate that as with the first conundrum, the need to slow down to attend to our relationships, obligations and the neglected, would have been offered as an antidote (Puig de la Bellacasa, 2017; Stengers, 2017; Wölfle, 2022). Youth may have named community, like family, as a beautiful conduit for transformation but also as romanticized trouble, that sometimes is simply a "pain-in-the-ass" (T. Lucero, personal communication, November 22, 2022). Despite identifying this, youth may have recommended we postpone sorting without the other team–preferring to stretch time to physically work alongside others *this time,* rather than next.

With this mention of time I might name this slowing as a counter to settler logics, and in opposition of the dominant progress narratives that govern most of today's rapid-fire science inquiries (Dietrich, 2016). Or I could go further by asking why we all, myself included, give "next time" a bad name, while "this time" is seen as ideal. I could ask why science places such a value on the present, rather than the past or future. We could discuss why we think the echoes of our work, or later reverberations of inquiry, are viewed as less powerful? Afterall, don't people lean in, often with more attention, to hear echoes? Could this be the same with this work? We could discuss minding as an embrace of ongoing revision without discrete end-points. Socio-ecological minding acknowledges time as an abstract construct and implies that the real power of scientific inquiries lies in their constant revision. As I sit here writing this, I even wonder what tense I should use to write these sections of socio-ecological minding if this here is data and analysis from months ago but also from right now and from moments in the future.

Lastly, if we had applied these thought experiments (Latour, 2004) to our protocols, our work would have reinforced not the quantity of data or trash collected, but care for ourselves, others, and sites of inquiry (Liboiron, 2021). For example, our protocols could have normed robust group check-ins to ensure that health and joy were being abundantly cultivated. Or maybe the sampling protocol could conclude with snorkeling and creating map entries to document what was inspiring about this site–methods that would record ecological abundance and hope, not just trash and destroyed marine lives. Pausing to practice socio-ecological minding would have created space for the doing of science in/with community to be abundantly transformative as a proactive way of being in this world.

Neglected Narrative 2. Desettling Dominant Inquiry Methods

As mentioned earlier, before youth took up their roles as researchers, the team of adult program leaders, including myself, set the goal of pushing against dominant ways of engaging in inquiry and specifically designed for dismantling North to South inquiry paradigms, ageist narratives about who can do fieldwork, and whose voices matter in inquiries. Although these were attended to in important ways, analysis revealed other toxic inquiry methods slipping into our work. And outside of a few stories, most of the critical interpretations of our fieldwork were a byproduct of my own doubts–narratives I kept to myself, not wanting to unravel any of the beauty from the Plastics Project. While logistical questions about how to approach this work (ie. permits, youth-responsive protocols, and gas consumption to sampling sites) accounted for some of my critical reflections, analysis revealed that I was most haunted by how nature was/n't consented to this research and how our fieldwork perpetuated ecological diasporas.

Nature's Consent. Dominant settler ideologies, coupled with beliefs that humans are separate from, and superior to, nature (Dietrich, 2016; Whyte, 2018) have created a precedent that assumes nature's consent to any fieldwork that is well-intentioned, especially that which has been deemed for "conservation". But with time observing other projects and seeing up-close the messiness of our own *doing,* I began to doubt these assumptions. In mid-July I wrote in my personal journal:

> "Who is this project accountable to? Yes, our goal is to use the data to inform community solutions but looking back I had assumed that the ocean would want us to remove plastics. Yet, we did not ask and how would we know the answer? Not sure why but I

feel assured that the answer is yes. Maybe this is me being guilt-ridden and going into "fix-it mode". We can't just do inquiry on whatever we like. What message does this send to the group?... Argh, how could we have asked [nature if this was okay]?"

These questions of how to respectfully conduct field research and consent nature surfaced repeatedly for me. For example, early in the summer we woke to a passed pelican strewn upon the rocky shore outside the station. At the time, there were no avian scientists around but many of us wondered about the bird's life and death. We circled the pelican trying to see what this seemingly healthy bird had died from. A few students were gently reprimanded by field station staff for poking at the bird. Several others considered if, like the birds they had learned about, this one had eaten too many plastics–after all, there was nothing perceivably wrong. Some of us even wondered if this was a serendipitous end, intended to provide us plastic pollution insight. For two days I prepared to dissect the bird with curious youth but kept this a secret as I did not want to disappoint anyone if I chickened out. Never having conducted a bird dissection before, I watched YouTube videos and read online about the dissection process, taking copious notes. I backed out in the end, not from lack of stomach but from concern that I couldn't perform the dissection with respect and honor. I worried the bird wouldn't want this and that I would teach the students that it was okay to impose themselves upon the deceased. This secret stayed with me until now, no one knowing otherwise. But now, I wonder what may have transpired if I had shared my thoughts with the group.

Although I was the only one in the group (that I know of) to think about consent in this formal way, students would often check if their actions were hurting invertebrates or antagonizing fish. While emerging briefly, these concerns remained neglected outside of one informal conversation between students.

Early in our fieldwork Romina instructed everyone not to remove soda cans found underwater because often these house communities of fish or invertebrates and this would be the equivalent of stealing their homes. Separate from the students, she and I hypothesized about what we would do if we had been on the research craft that pulled a floating crate out of the water in New England, displacing numerous tropical fish that had migrated hundreds of miles with it (De Wolff, 2017). Students sometimes overheard these discussions, but they never added their opinions, and sadly we didn't ask. Then one day Dario pulled a transparent snack bag from the

rocks outside the station and a few students naturally crowded around to see what was on the plastic and discuss what should be done (see Figure 6).

Figure 6.

Students Spontaneously Engage in Socio-ecological Minding about Plastic Debris as Habitat

Dario: Look, look Romina! This plastic was there (points to water and raises snorkel). There are these…What are they?

Romina: Yes, let's have a look. (Several students nearby circle around to see. Romina leans in and touches them softly.) Oh, okay. What do you think they are? (Students offer different guesses and one says sea cucumber.) I believe so too.

Dario: What should I do with this?

Gus: Go put it with the trash I found (points to small pile on the beach). I will take it up.

Romina: And you Lia, what do you think?

Lia: Are these babies?

Romina: I am not sure, but I think so, yes.

Lia: Are they eating this? Or is this their home? Maybe this is like the cans, and we should just put it back?

Alessa: Oh yes, I hadn't thought of it that way but now you saying this it makes me think that this is their home—how would you feel if your home was taken away? But it is also going to

breakdown into a million pieces and what we thought was right may be the death of so many things.

After a little more debate and receiving final approval by Romina, the sea cucumbers were removed and gently placed on a rock nearby—students had deliberated that taking proactive caution was better in the long run than not removing the plastic. The conversation was over, and our team never returned to the idea of consenting nature in our attempts to conserve it. Additionally, this story was only partially narrated, as no one mentioned the ecological diaspora we were forcing upon these baby sea cucumbers or the consequences of transplanting them. So, like many of the narratives shared throughout these findings, this set remained in the wings, unaddressed by youth or adults. And I held my concerns close, not wanting to seem overly sentimental because the summer program revolved around this fieldwork. And also because I worried about hearing a resounding "do not consent" and not knowing how to move forward.

Ecological Diaspora. My personal doubts about consenting nature and the case of instigating ecological diaspora through our inquiry seeped into other parts of the work—These critiques became unshakeable shadows lurking at the periphery of this work. For instance, about a week following the sea cucumber discussion, the tension of ecological diaspora came temporarily into focus again. I was alone in the evening analyzing week old samples and realized that the microorganisms buried in the detritus-rich sample had died—as well as the seaweed. The smell was pungent and after a speedy analysis, I tossed everything (sans plastics) back into the ocean to decompose. Feeling guilty, I prioritized analyzing samples moving forward to keep the organisms accidentally mixed-up in our sample alive... I didn't want to be responsible for killing marine species through this work.

No more than a week later, I was tossing the still alive seaweed and plankton back into the water after having separated out any microplastics, and I thought "these are from an island at least a mile away!! Crap, have I just introduced a species here?!? This sample didn't even have any plastic in it—have I done more harm than good? Created more shit with our research?" As with considering nature's consent, I now wonder, what brilliant solution might students have offered to combat the forced ecological diaspora we were enacting? If I had shared my concerns with the group, what perspectives would they have illuminated that I had not considered? And

why was I so fixated on helping students arrive at a "clean answer" when they were already swimming in this mess with me?

Practicing Socio-ecological Minding. This collection of neglected narratives, that were never storied by our team, reflects problematic settler logics (Dietrich, 2016; Whyte, 2018) that sit at the epistemological foundation of many conservation and environmental justice projects. Pausing as a team to acknowledge the ways that our field work unintentionally displaced and exploited species and sacred places would have created a powerful opportunity to bring into the light ways that our research perpetuated harm to the bay.

We could have then discussed the ways that many conservation projects aim to "save" nature, or even restore nature–which sub/consciously reproduce Anthropocentric top-down problem-solving approaches which largely fail to foster justice for multispecies and more-than-being beings (Emden, 2021; Whyte, 2017). Practicing socio-ecological minding could have facilitated discussion among our youth about how pre-colonized ways of the world can never be fully realized (Whyte, 2017; Liboiron, 2021)--and instead our focus should be on doing our best to uphold our many obligations and steward what exists. As Dr. Max Liboiron from CLEAR reminds us, entanglements do not equate to relations and especially not to good relations (2021). Helping students unpack that proximity and intent are not the same thing as upholding obligations or being in good relations is important to how they will enact and participate in environmental inquiries in the future.

Furthermore, there is a growing global movement to recognize multispecies and landwaterstarsair (Sanchez, 2023) as legal beings deserving of rights (Whyte, 2017; Taylor, 2019). Often this legal representation is applied against those actively bringing harm to these sites but I wonder how fieldwork, and the *doing* of science education more broadly, can preemptively recognize the rights of lands and waters in methods—there should not be any assumption of good intention, protection should be etched into protocols rather than tacked on at the end (Liboiron, 2021). In our case, this would require learners to recognize that, like other forms of our more-than-human world, dominant science has a broken relationship with water. Our understanding of what lies below the surface, or even at waters' edge, has been a casualty of ongoing colonization, modernization, and human-nature culture divide and domination over nature. Ways of exploring, testing, presencing, photographing, sampling, monitoring and even restoring are entangled with dominant society's and anthropogenic motives. Water is rarely

asked to voice its opinion or review work and therefore never given the opportunity to refuse science.

Relatedly, this process of consent must consider what stories are told about these waters—being sure to avoid victimizing nature and devaluing it through negative interpretations of findings/evaluations—when the power of water is minimized this does little to represent the problem or potential flourishing futurity.

If I was to turn back time and engage students in socio-ecological minding I would have also asked, "does every mystery need to be solved? And can every mystery be solved? I would have asked the youth why mysteries are not property and why not every mystery should be solved. I would have prompted them to think with me about the mystery of the pelican and what we should have done. For the adult researchers on the team (like myself or Romina) to script rules about how to support marine species living on/in/around marine debris and expect students to blindly follow these without rigorous discussion, strips youth of agency and allyship with the ocean. And it ignores knowledge or obligations they may have of/to the waters. But slowing down to critically read these events, like the one that unfolds with the sea cucumbers or the pelican, would have given youth an opportunity to discuss the problem at hand; even if the conclusion is that sometimes there isn't a single "right answer".

Furthermore, as suggested in the last neglected narrative, what if slowing down was also about more than slowing per say. What if it was also a disruption of time constraints placed on research– where time stretched, crunched, and folded on itself dismissing boundaries of data collection, analysis and reflection and was designed for endless revision and deep embrace of long-term learning. This slowing down then would be an acknowledgement that time is another arbitrary constraint of dominant science designed to imply objectivity.

To sow these mindings, some questions we could ask to practice socio-ecological minding include:

- What do you think about leaving human-made debris in the water (like soda cans) but not everything? How do we decide what to remove and what should stay? Who might be impacted by our good intentions that we can't see? What should we do?
- What makes fieldwork complicated and messy? What do we do about this?

- What message are we sending about land and waters when we do investigations on/to them? How can we avoid victimizing nature moving forward while still shining light on ecological destruction?
- The world is full of mystery, how do we decide which mysteries to try and solve and which should remain unsolved? Are mysteries property and what does this mean for how we conduct our research? What role do the Earth's mysteries play in how we act and engage with nature?
- When does research "start" or "end"? How might science look differently if we accept that ideas and research are not static? How might we never be done with an inquiry? How might analysis be ongoing?

Conclusion and Implications

As seen in the conundrums and neglected narratives minded in this paper, our entanglements flood and muddy the doing of science. Nevertheless, by engaging in socio-ecological minding we interpret and narrate the world we fail to create, which are generative first steps toward transforming any system toward justice (de Beauvoir, 1947; Dilts, 2017). The practice of socio-ecological minding sits in stark contrast to how science has been conceptualized in white, settler spaces (K-12 schools, universities, field stations, most labs, etc.). By taking up a multilogics approach that creates a lens, or a prism of lenses, to analyze, narrate and theorize about slippages, answers the call for science education to become more inclusive of diverse epistemologies and ontologies. These narrations help loosen the grip settler logics and dominant norms have on the doing of science. Socio-ecological minding acknowledges students' constellar youth knowledge (Arada, Sanchez & Bell, 2023) and works towards expanding students' historical understandings, critical consciousness and sense of ecojustice (Fazio & Karrow, 2015; Basu & Calabrese Barton, 2009; Bang & Medin, 2010). Moreover, these critical narrations challenge us to consider how to foster human and more-than-human socio-ecological flourishing (Haraway, 2016) and how the consequential work of science is to care and apply critiques as offerings for a transformed future.

However, as I experienced, educators facilitating socio-ecological minding shouldn't depend on these moments to organically unfold. They may, as youth are brilliant and have diverse theories and lenses (Arada, Sanchez & Bell, 2023) they bring to the work, but in many

cases these critical narrations must be welcomed and then guided away from dominant narratives about science research. The five questions used to analyze the data provide an entry point for these discussions but ideally, with time, the questions would organically form in response to the slippages. The point here is that socio-ecological minding is a dialogic practice of care and collective consciousness that should flow abundantly through science learning and research to inform the inquiry moving forward.

Knowing what questions to ask and how to pull varying logics and theories together I anticipate will be a challenge for practitioners who have resided under the umbrella of settler logic, or "one right way", for so long (Dietrich, 2016; Whyte, 2015). Future work needs to consider: how do teachers develop the ability to support socio-ecological minding? These apprehensions speak most harshly of my own blind spots, concessions and troubles because I have realized that conundrums our team faced in the Plastics Project mirror ones I encountered over my 10 years of classroom teaching. I recognize now that if I had sat in the discomfort of these conundrums and neglected narratives earlier, I may have been more accountable to the youth I taught and the science they, and I, hoped to realize. However, as my critical lens was embryonic, I also may have failed to see conundrums altogether. Therefore, we must support educators in weaving their own lenses of multilogic sensemaking and recognize the vibrant worlds and theories, like the horcruxes, students are already drawing on.

Additionally, mandates for more partnerships between K-12 science programs and field stations/sites, or professional researchers, provide fertile ground for engaging in this practice of socio-ecological minding on a larger scale and observing how this collective critical consciousness impacts the designs, iterations and outcomes of these programs. As schools, field stations, and other organizations design STEM programs with/for youth, especially related to marine sciences, there are ways we can do this better, and must. The lessons evoked from socio-ecological minding need not stay as melancholic critiques, but they should become offerings for radical change. And so, in this spirit, I provide some starting questions for facilitators of environmental research, STEM educators to ask themselves and others as they engage in designing these programs:

- Is this engagement intended just to cultivate wonder and relevancy and at what cost?
- Is fieldwork moving us toward something greater than individual learning or outdoor experiences?

- What harm is unfolding, unintentionally, because of this well-intentioned desire for kids to connect with nature?
- What spaces are there for minding and revising our learning and work?

While promising, socio-ecological minding doesn't come without pitfalls. One of the big dilemmas that spans before us in taking up this work is how do we move forward with the *doing* (including teaching and learning) of science in ways that doesn't lead to mistrust or disinterest in science? How does socio-ecological minding become an authentic form of analysis and dialogue about what the world could, and should, be so that science is not dismissed by students and the larger community? Max Liboiron reframes this dilemma beautifully, asking*:*

> The methodological question is: how do I get to a place where these relations are properly scientific, rather than questions that fall outside of science, the same way ethics sections are tacked on at the end of a science textbook? ...How do I, as a scientist, make afterlives and good Land relations [and other neglected narratives] integral to dominant scientific practice? (*2021)*

Here Liboiron is challenging us to acknowledge the legions of skeptics of science, who eagerly await opportunities to resist truths that are inconvenient to them (ie. climate change, mask wearing, Indigenous Science) and those of a different, yet related legion, who embrace the reductive and impoverished nature of "proper science". This second group sits waiting to shoot down any "softening" or expanding of settled, dominant science, which often means that more expansive forms of science are banished to footnotes or comments of an additive nature.

As scientists and science educators we can attend to this tension by normalizing socio-ecological minding in our own research. Smashing our protocols, findings, discussion, and heart work together may be mess-making. It may throw us into "the perpetual stickiness" (Akomolafe, 2020) but it is also a form of refusing the traditional compartmentalization of research that occurs, transparently acknowledging our own "slippages" (Laymon, 2020), and our own failures in realizing justice (de Beauvoir, 1947; Dilts, 2017). By openly practicing socio-ecological minding as adults within the sciences, we can ensure that the critical readings and narrations of the stories we are actors in, or are purview to, are intentionally given time, space, and support for fostering environmental accountability, community, and ecological justice. We can design curriculum and write experiment/lab protocols that facilitate individual and collaborative socio-ecological minding, and we can do the uncomfortable work of reflexively engaging in socio-

ecological minding in community alongside each other, and when needed stopping our work and redoing our methods of research.

To conclude, my hope is that you too will be lucky enough for "agua mala" to sneak up and bite in unpredictable and motivating ways. And that through socio-ecological minding the sediment can settle to reveal conundrums and neglected narratives that when critically storied can create restorative new currents for learning and working towards environmental justice.

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SECTION 3

Designing, Sustaining, and Evaluating Environmental Justice Projects: The Critical Community Science Tools

Originally, I created the Critical Community Science Tool featured in this paper to vet ideas and evaluate the work of a Youth Participatory Science project (Morales-Doyle & Frausto, 2021). In this project a group of Mexican students, ages 7-17, from a small fishing community along the Baja peninsula worked with scientists at a marine field station to study the important phenomenon of plastic pollution and viable solutions. The tool helped ensure that this "Plastics Project" centered the real histories, questions, and concerns of the students and other community members as related to the phenomenon—effectively transforming the learning from a straight-forward outdoor environmental science unit into an expansive project aimed at fostering waste justice.

Those of us who teach science (informally or formally) understand that we are living in a precarious environmental moment and feel obliged to facilitating learning that, like the Plastics Project, works toward realizing environmental justice. Educational organizations on every continent have encouraged educators to teach about environmental problems—centering curriculum around environmental stewardship and ecological futures for everyone. Regardless, knowing *how* to engage youth in science learning that disrupts systems entrenched in environmental destruction, that cultivate learners as change agents for environmental justice remains under-explored (Philip & Azevedo, 2017).

One-way educators are centering these issues is through citizen science or place-, project- or problem-based learning experiences which prompt youth to take on the roles of scientists and/or activists studying environmental justice phenomena in their own communities. This approach provides an opportunity to engage young people in doing much more than regurgitating facts or constructing seemingly neutral social and cultural explanations of phenomena (Calabrese Barton, 2012; Bang & Medin, 2010). Whereas most science learning done by youth is rarely designed to explore consequential issues that transect science and society (Bang & Medin, 2010), engaging youth as scientists studying local environmental phenomena can powerfully blur the lines of who, where, how, and for what science learning occurs—important first steps in realizing environmental justice. However, learning outside and under the

co-leadership about local EJ topics does not automatically equate to young people being more engaged as sensemakers or agents for justice. Science educators need support planning, maintaining, and evaluating their work with youth around these types of phenomena.

In this article, I introduce the CCS Tool, which centers science learning projects toward youth, community, and environmental justice. I provide examples of how it was used within the Plastics Project and how science educators used it to design unique learning opportunities for their students.

What is the Critical Community Science (CCS) Tool?

Like most Youth Participatory Science projects, the Plastics Project morphed with time in response to the participants' wonderings and growing explanations of the phenomenon. Youth developed and iterated upon protocols used for measuring and documenting plastics debris found conducting 40 surveys across different beaches in the local archipelago. They also built research equipment from repurposed trash, taught guests how to collect data, communicated goals and findings of the project with others, led community beach clean-ups, created social media posts and videos to raise awareness and pushed their adult partners to take a more proactive approach to the problem. (To learn more about the youths' exploration of the plastic pollution phenomena, check out this StoryMap *Centering Baja Youths' Ocean Plastic Wonderings & Expertise*.)

As the Plastics Project morphed, so too did our use of the CCS Tool. As discussed above, *how* to engage young people in science learning that realizes environmental justice was something, like other science educators, I had not been explicitly taught to do and I needed some guidelines (even if flawed) to hold myself accountable to attending to matters of justice throughout the project. So, I turned for inspiration to a tool from a different project that I was working on at the time (E2AST), which had been designed to support classroom teachers in noticing students' ideas from a critical and cultural perspective. Unlike that tool, the CCS Tool aims to be a guide for engaging as scientists in exploring and addressing real-world environmental problems–there is a heavy focus on physically conducting science investigations, learning outside, with community beyond the traditional classroom walls, and studying science to make real change.

Because science education, and scientific research, often fail to recognize and honor sociopolitical and cultural connections to topics of environmental concern, it is even more

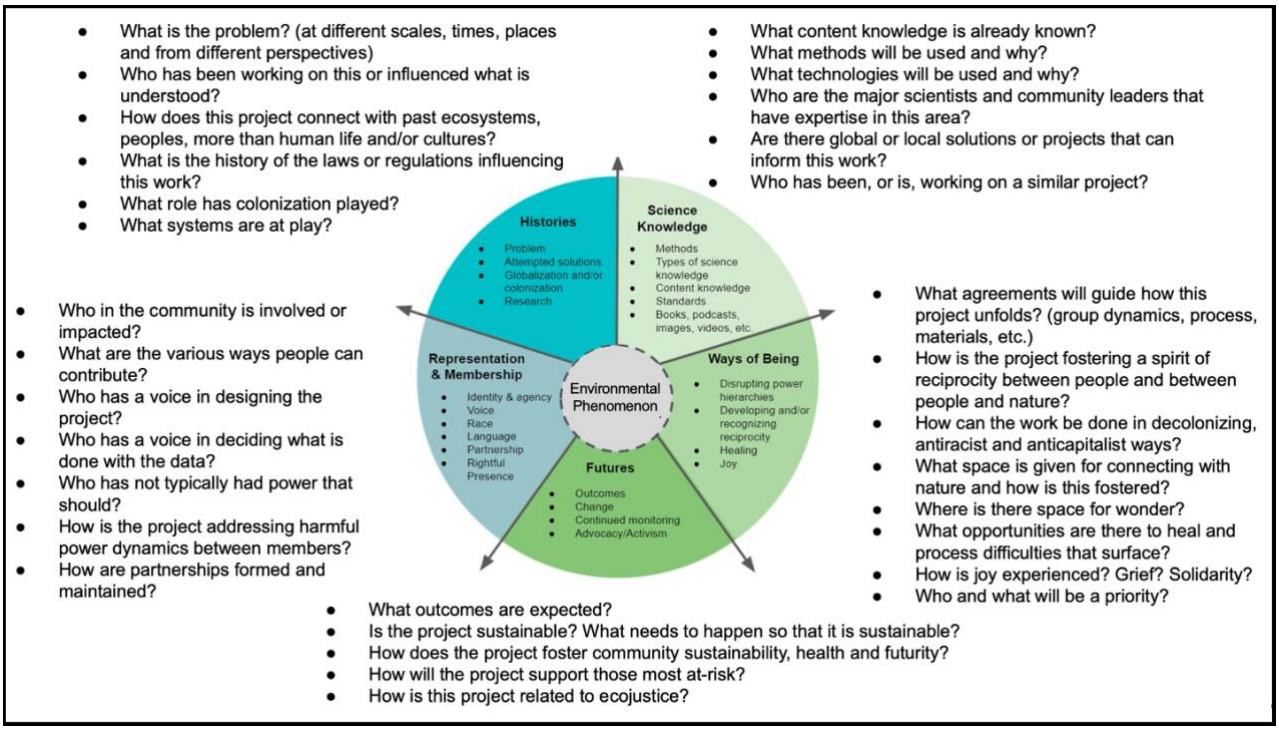
important to consider these when supporting students in studying phenomena. If the ways that science and society have (and do) intersect remain invisible, it will be impossible to rectify environmental injustices or prevent these same atrocities from occurring in the future. As shown in Figure 1, the CCS Tool prompts users to reason holistically about a phenomenon in consideration of the history of an issue or project, how the work should unfold, what evidence should be collected and how, whose expertise must guide the work and toward what futures the work is moving. As these are complex ideas often segregated from scientific reasoning, these ideas are parsed into five dimensions: Representation & Membership, Histories, Science Knowledge, Ways of Being, and Futures.

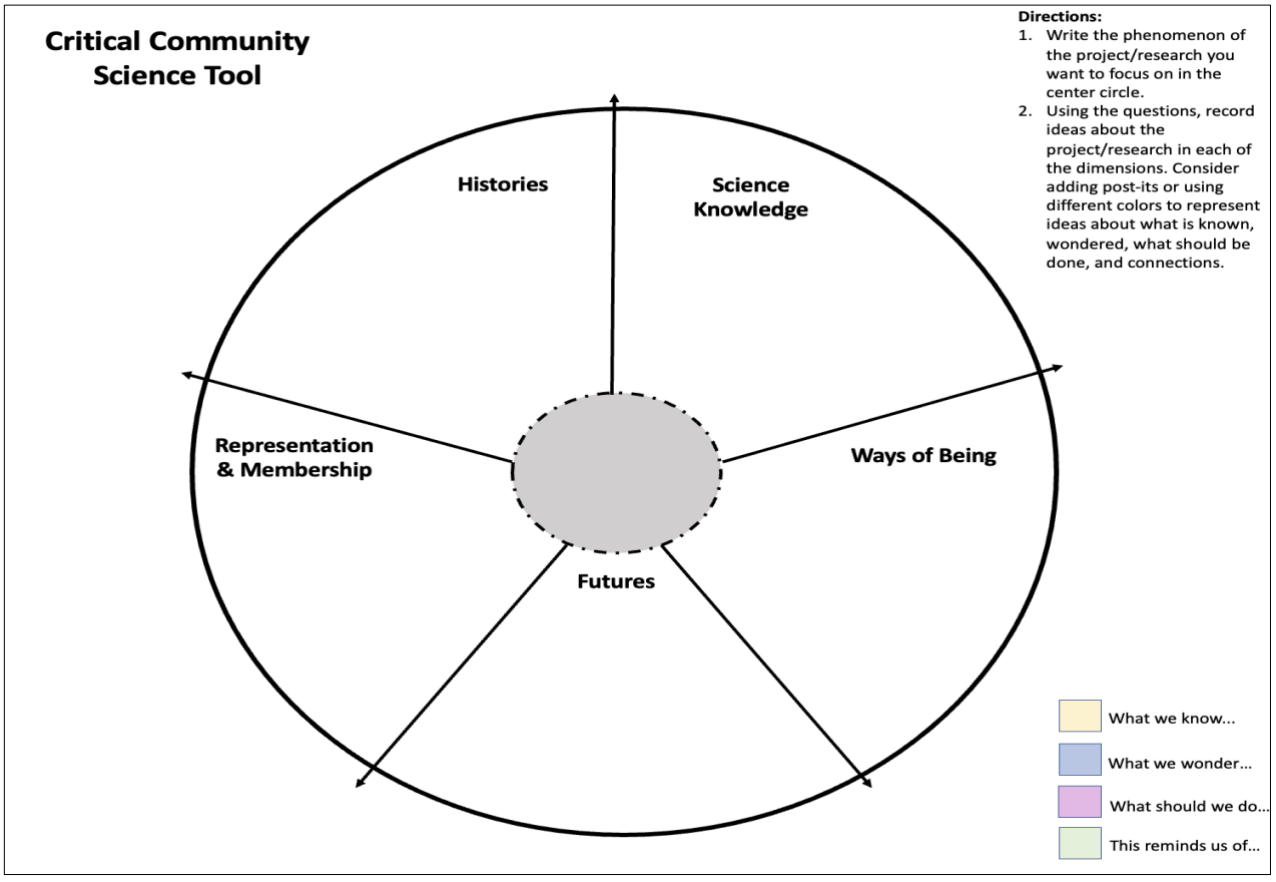
While each dimension has a nuanced difference that is important to attend to, it is the overlaps between the dimensions that can be particularly powerful—like a whole that is more than the sum of its parts. Considering the dimensions together could be the difference between simply naming aspects, entities, or components related to the phenomenon, and allowing these ideas to cross-pollinate so that the phenomenon is understood more comprehensively. In this way, the CCS Tool can help educators avoid isolating ideas and overlooking common pitfalls that negate or trouble environmental justice projects.

For example, the "Representation & Membership" dimension on its own helps identify specific actors who have been involved or impacted by the environmental phenomenon that otherwise may be unrecognized. But, when what is known about these actors informs the "Future" dimension, for instance, imaginings of life beyond the issue of environmental injustice being studied becomes more representative of the lives most impacted. This is necessary for upholding obligations to this community.

Figure 1.

Front and Back of The Critical Community Science (CCS) Tool





As the Plastics Project expanded pursuing students' wonderings and taking community action, this tool became a catalysis for iterative criticality and reflection. In the early stages the CCS Tool was simply a personal graphic organizer that I had scribbled out in my field journal to plan activities and avoid common pitfalls of environmental justice projects (e.g., starting from "scratch", which can erase the work and learning of community members who have already been working to address the issue). Many of the first entries I made reflected the original goals behind the Plastic Project—ideas about disrupting dominant science narratives around what counts as legitimate forms of science and who can do science.

For example, under "Representation and Membership" I accounted for surveys that had been designed, from the beginning, to protect space and airtime for eliciting even the youngest and quietest youth's successes, tensions, and new ideas–the goal of these surveys was to reinforce and magnify the students' membership in the work on a regular basis. The "History" dimension challenged us to research and learn from past community members' waste pollution management efforts. In my journal I documented our learnings about attempts to build a formal waste collection site, past community initiatives to ban plastic bags, and the work of other local organizations combating marine plastic pollution. Under "Ways of Being", I had scribbled "science equipment from upcycled and discarded objects–don't add more trash to this world." This idea was founded on wanting to keep the project's plastic footprint small and practicing alternatives to consumerism.

Although sparse initially, over time each dimension began to overflow, except in areas we were failing to deeply consider and design for. For example, despite the Plastics Project aiming to create a healthier future, the "Futures" section remained blank outside of two small notes I had made about "cleaner beaches" and "increased care for the local environment". After finally sharing this realization with other youth and adults working on the project, the group decided to shift the entire project. The tool had allowed us all to see and agree that if we were not acting for a better future, there was no justice being sought. In response, we scaled back field research and beach clean-ups to focus mostly on larger pieces of plastic debris, which allowed youth to dedicate more time to creating social media campaigns to eliminate single-use plastics, installing cigarette butt collectors around town, talking with businesses about reducing waste, and finish mapping areas of the bay that needed more regular monitoring. In the meantime, some

of the adult project partners applied for grants to fund wide-spread preventive community action. The CCS Tool had made explicit our shortcomings and prompted change.

More Ideas of How to Use the CCS Tool with Youth

In hindsight, I wish youth had directly interacted with the CCS Tool themselves. With a little support, youth easily could have used the tool in sophisticated ways that would have challenged reductive ideas about what youth are capable of and the roles they play in authoring environmental justice. Now, it is easy to imagine the tool as part of a large poster hanging in our lab at the field station—The phenomenon "Marine Plastic Pollution " penned in the middle and the dimensions flooded with jottings and post-its of related ideas, connections, questions, or tensions from the youth researchers. We could have switched the poster out periodically to help map the evolution of our questions, our objectives, and project activities.

In this imaging, I also wonder how students, in formal classrooms or informal programs, might be tasked with showing their scientific learning and critical thinking through the CCS Tool. A printed copy could be kept in a team or individual science notebook for youth to periodically to add notes as their ideas shifted. Youth could collect artifacts or evidence to be examined through different dimensions of the tool, or it could be used for designing new scientific research projects. I also think the tool could function like an anchor chart, visible in learning spaces to constantly reground the work in accountability to the past, future, and community. The CCS Tool could also be used to collect and/or organize stakeholder perspectives before launching environmental justice projects.

Science Educators Use the Tool to Plan Outdoor Environmental Units or Programs

Realizing that the CCS Tool was becoming pivotal within our own work, I wanted to understand how other educators might use it to inform their own environmental science work. To do this, I pulled the tool into a short series of seminars I led with Master's students visiting the field station to complete their field research course. Although a central goal of the Master's coursework was to understand participatory forms of science (ie., community-based science and citizen science), few of the educators had personal experience engaging in this type of work or thinking about fieldwork as an avenue for attending to environmental injustices. Furthermore, this field course was not designed around environmental justice science learning. So, my

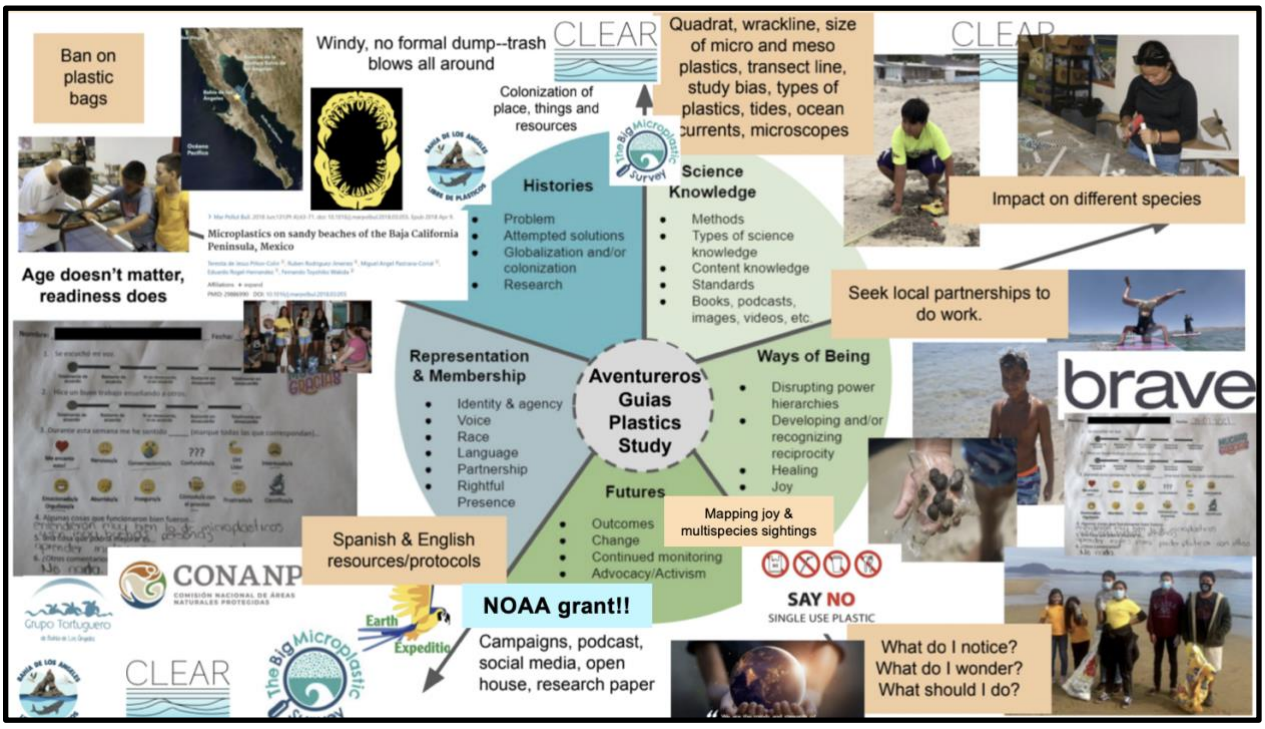
contributions were an important, but admittedly tangential element of their learning. Despite this, the educators' unique positionality (a blend of science teachers, informal science educators, and field scientists) lends well for thinking across formal and informal learning spaces about what science educators are prepared for and what they need support around when teaching environmental justice phenomena.

Below I explain how the CCS Tool was taken up with the educators and ways the tool supported thinking about how to teach for environmental justice by identifying topics or points of tension that they needed further support with.

In the first session the educators created group posters using the tool to outline what they knew and had learned over the past several days working as volunteers under the guidance of the youth on the Plastics Project. They added connections and questions to the tool, which we used to discuss more about the project and then discussed how the CCS Tool might apply to their own teaching/research. Then, as shown in Figure 2, I shared my own example of the tool to communicate and reflect upon the aims and work of the Plastics Project with the student educators more deeply.

Figure 2.

CCS Tool Became Graphic to Explain the Plastics Project



Analyzing field notes, formal logs, and audio recordings of the seminars revealed that most of the Masters' students were invested in thinking about how environmental justice intersected with their current role in science. Furthermore, many of the formal science teachers shared that in the past they had wanted to center matters of environmental justice but had not been sure where to start or how to ensure that the project didn't cause more problems. A science teacher with four years of classroom experience from Maryland who also had a passion for addressing plastic pollution shared, "I have wanted to do something like this for a while…My students could totally do this. They need to be learning science that helps."

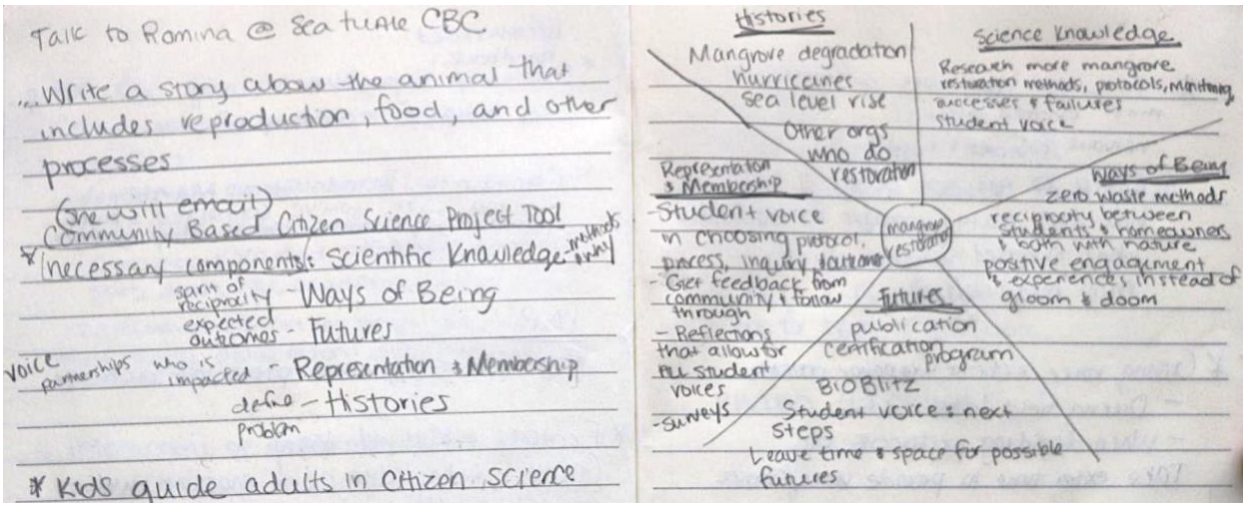
On the other hand, quite a few educators from outdoor education programs, and even a few classroom teachers, who already lead youth in studying environmental problems, realized that their projects had room to improve. An after-school educator said, "I'm realizing teaching for environmental justice is complicated…It should be more than just going outside, collecting some data related to a problem, and then talking about it." Similarly, a biology teacher of 15 years said,

> Our highschoolers collect data on different issues near our school and we have been working on reporting it but looking at this, I hadn't really considered student voice in these projects, but why not? It is something that when I step back and am honest, I had been considering but it is long overdue—it is something I need to make a priority and talk to others about.

During the following sessions, the focus became unpacking each dimension of the tool and related prompts as a whole group. I printed blank templates of the tool and challenged everyone to select a phenomenon specific to youth environmental learning and justice. On these blank templates, or in their own journals, the educators drafted ideas and worked in small groups to think through some of the questions. To conclude, the teachers shared their drafts with each other (see Figure 3), discussed noticings that surfaced across projects, and asked for help thinking through their specific contexts.

Figure 3.

Artifacts of Educators' Engagement with Tool



Although the tool, and particularly the critical questions associated with each dimension, spurred educators to rethink what "teaching for environmental justice" entails, there were some broad topics that they needed support around understanding or mapping onto their own work with youth. These topics included:

1. More-than-humans as stakeholders
2. Refusing to generalize places and science as an objective endeavor
3. Fostering ecological hope

More-than-Human Stakeholders

Across the sessions it became obvious that most of the science educators present were unfamiliar with the terminology "more-than-human" (Abram, 1996; Wall Kimmerer, 2013). For example, when I asked for suggestions on how to improve the tool, a few educators suggested "making the terminology more accessible" and named "more-than-human" as the primary change needed. While this is not something I anticipated, I initially agreed with them because language should be accessible. However, over time I saw that it wasn't just the terminology but the concept itself was unfamiliar and I wondered how keeping this term on the tool could provide an important point of learning for the educators. Rarely were other species or parts of nature listed on their tools and not once across all the tools were they added to the Representation and Membership dimension. Consider as another example the following event:

Quietly settling onto a bench at the back for the classroom I had arrived in time to hear the presenting group of six talk about developing solutions for restoring a river. One of the students offered up a joke about fish being stakeholders, which elicited quite a bit of laughter. The group began to move on, but I couldn't help myself, "I don't get it. Why didn't you consider the fish themselves to be stakeholders?" The day before we had sat outside, and I had played an audio of Potawatomi biologist Robin Wall Kimmerer reading from her book Braiding Sweetgrass about bays (or "Wiikwegamaa") being alive and deserving protection like any other person. The conversation was brief but was rich with thinking about how viewing parts of nature as living beings with their own voices might change how humans acted. Had nothing sunk in? The man at the front of the room looked around with a nervous grin. "Well, we of course want to bring the fish back. So, I guess they are sort of like a stakeholder, but we really think about who would be impacted–you know?" I slowly nodded to show I had heard. The consensus in the room was that stakeholders are humans (ie. scientists, local leaders, fishermen) who are impacted by the problem and/or solution, not other species, or parts of Earth.

The concept that species and parts of this world that are not human, should be centered in environmental justice as stakeholders was novel to most. In this moment, it became clear that, despite being in a program designed to improve conservation efforts and science teaching, definitions of conservation and environmental justice were still firmly situated in a western Eurocentric paradigm that reifies human superiority and saviorism of nature. However, it is essential that the histories, voices, and futures of those who have historically been marginalized or harmed are centered—otherwise our attempts to realize environmental justice will simply continue to reproduce the same problems. Deeply understanding this requires time, but also ways, like the CCS Tool, to remind and hold us accountable for planning and teaching environmental science differently. This analysis led me to add questions in several dimensions to prompt for more-than-human thinking.

Refusing to Generalize Places and Science as an Objective Endeavor

Another trend that surfaced was that when the science educators took up the CCS Tool for the first time, they frequently stripped whatever project they were examining of specificity, especially regarding the place and assets of this place. Some educators even scrubbed the Plastics Project they had been deeply engaged in, of specific groups or histories they had just learned about. As they engaged with the CCS Tool around their own projects, I noticed this trend did not improve, but worsened. For example, community organizations or individuals remained nameless, it was unclear what local species were being referenced, where the project took place, biogeographic patterns and solutions were ambiguously broad. One science educator asked, "How is history and science knowledge different?

These patterns reminded me that because of the broken world we live in, many people want quick solutions to realize environmental justice and have been taught that creating projects that are generalizable across places are ideal. Although possibly well-intentioned, this is the equivalent of conservation colonization—the unique identities of places are erased, are oversimplified, and replaced by these universal approaches.

Numerous science educators were also surprised that our methods to understand and address the plastic pollution phenomenon kept morphing. As they used the CCS Tool to unpack what they knew about the project they asked questions about, "should we write the methods that are current or past methods?" And "do we put the meso- and macro-plastics methods in or the microplastics?" At which point, I encouraged them to add both because together they inform our current and future work in important ways that are important to remember and reflect upon.

As the educators drafted responses in their own tool, I found myself talking with many of them about whether keeping field methods the same over a long project is ideal or if the methods could change between samplings and the impact if modifications were made. Frequently I asked, "Where is the iterative nature of science and change represented in your project? How will you navigate changes?" In response, there seemed to be consensus that you stick with methods, no matter what. Changing the research appeared scary and even "unscientific". One classroom teacher said, "even bad methods will teach students something and students will learn this when their data has no clear pattern." Initially, this sentiment was shared by quite a few of the educators and reminded me of where my own thinking had laid just a few years ago, when I had prioritized lessons about objectivity and consistent data collection. However, collecting data that

can't be used to identify the extent of problems or facilitate change is fruitless–why continue spending time, materials, and effort on data that are not powerful?

Fortunately, as the educators used the CCS Tool, these patterns became obvious to them as well and I could hear them talking about "letting go of rigid methods" in their own projects so the efforts of the youth would mean something. Moving forward, science educators need to continue disrupting the notion that generalizability and objectivity will realize environmental change.

Fostering Ecological Hope

The last topic the science educators struggled to map out was how the future was being accounted for in the environmental projects they were personally evaluating or designing. When the future dimension was attended to it was often perfunctory "sustainable solutions." Several educators admitted they were struggling to imagine generative ways forward given the realities of the programs or schools they taught in. Among other challenges, they surfaced time constraints of programs/units and/or limited funds to sustain a project—both tensions that elevate the need to do this work in community and across an extended, possibly multi-year, time scale.

As a collective we brainstormed together how to plan and evaluate authentically for this dimension. It was from this conversation that I tweaked the tool so that rather than center the problem, the phenomenon is placed in the center–which as one teacher wisely suggested, would open this work to be more than understanding the problem. Here is a list of some of the other ideas brainstormed:

- Youth could create maps, zines, artwork, bulletin boards, podcasts, etc. that share stories of joy, wonder, and flourishing they encountered while engaging in the project,
- participate in or leading community events to advocate for changes to improve the issue,
- find and partner with local or national groups already working on the problem–this will help make the work more economically and socially viable and sustainable,
- and engaging in tasks that elicit imaging and speculating solutions and futures beyond the problem; an important step in eventually actualizing change.

There were other solutions brainstormed but the takeaway here is that the CCS Tool itself will not provide answers or ways forward but will help identify areas to improve how we investigate and attend to environmental justice phenomena with youth.

Implications

While these nascent findings need further exploration, the CCS Tool can be helpful in moving youth participating in citizen science or place-, project- or problem-based learning toward understanding and realizing true environmental justice—rather than avoiding environmental justice phenomenon or superficially attending to the issue. The dimensions and corresponding questions prompt science educators to closely inspect and improve learning opportunities.

As we face numerous issues of environmental degradation and loss at a planetary scale (ie. climate change, marine pollution, mass extinctions) it can even be easy for environmental educators to shy away from science learning that is situated within sociopolitical and cultural histories or to jump blindly into the mess, but these responses will not seed the change this world needs. We must remember that, when done thoughtfully, learning about phenomena from a critical lens can serve as a powerful antidote to environmental injustices.

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CONCLUSION

This dissertation makes several important contributions to the field of science education. As explained in the Introduction and then in greater detail in the three main sections, the findings challenge us to first rethink the ways that we oversimplify ecoemotions and often dichotomize grief and hope–as if one is better than another or as if one serves as a way forward more than another. The first paper also presents the youth's uncolonized understanding of the ocean as a wise and powerful teacher who assists in metabolizing ecogrief and worlding futures as a radical act of hope. Other important implications of my dissertation include the practice of slowing down to collectively narrate, question, and improve how science unfolds as a mechanism for realizing more justice worlds.

Beyond contributions that this dissertation makes to the field of science education, I have grown personally and as a researcher in immeasurable ways. In the first paper I share a quote from Idra essentially reprimanding scientists and educators for mistaking book knowledge with knowledge developed in the ocean alongside whale sharks. As I wrap-up this book(ish) knowledge, her point couldn't resonate with me more... Reading about dissertations is different from dissertating. And enacting Critical Participatory Ethnographic methods in situ, or in the flesh, is endlessly more complex, informative, personal, communal, exhausting, and transformative than I could have ever anticipated.

This is to say that through this process I learned far more than I had set out to. Some of these lessons are easy to list, like: field notebooks are not diaries–you need to be able to read them eventually, how to store loads of data securely, how to write and win grant money, how to jump around an interview protocol so the conversation flows, how to use photo-elicitation interview techniques, how to create participant portraits as an identity-laden approach to data analysis, or how to write a better conceptual framework. Or even how to fish junk out of the desert to collectively build upcycled field equipment. Other lessons I feel like I am still learning, such as: how to understand the heart behind people's stories, that showing up transparently is always best, how to listen between words and listen with care, and to always forgo interviews to help complete homework or play Dance Dance Revolution. I learned personally that the hierarchies of research are real but that by inviting others over to eat or drink whatever is in the fridge and play with my baby while sopping wet and talking about data will help melt away these power dynamics. The lesson here is that showing up, even in your hot mess state, does wonders

to developing a relationship based on reciprocal authenticity. I also learned and unlearned and relearned to see my own plastic footprint. I was reminded to show-up for youth as my full self always–none of this pretending to be curious or having questions; as a science teacher I should bring my real wonderings and ideas because the youth will always keep up, and they will be more apt to bring their full selves. So many lessons, both big and small.

To conclude, I want to acknowledge that I came to graduate school wildly biased that if youth were given the chance through science education, they could solve our world's woes. And after a decade of seeking evidence of this brilliance I have found a lifetime of evidence to draw upon. Thank you again Aventureros!

Appendix A

Study and Plastics Project Timeline

Figure A1. Timeline of Dissertation Data Collection

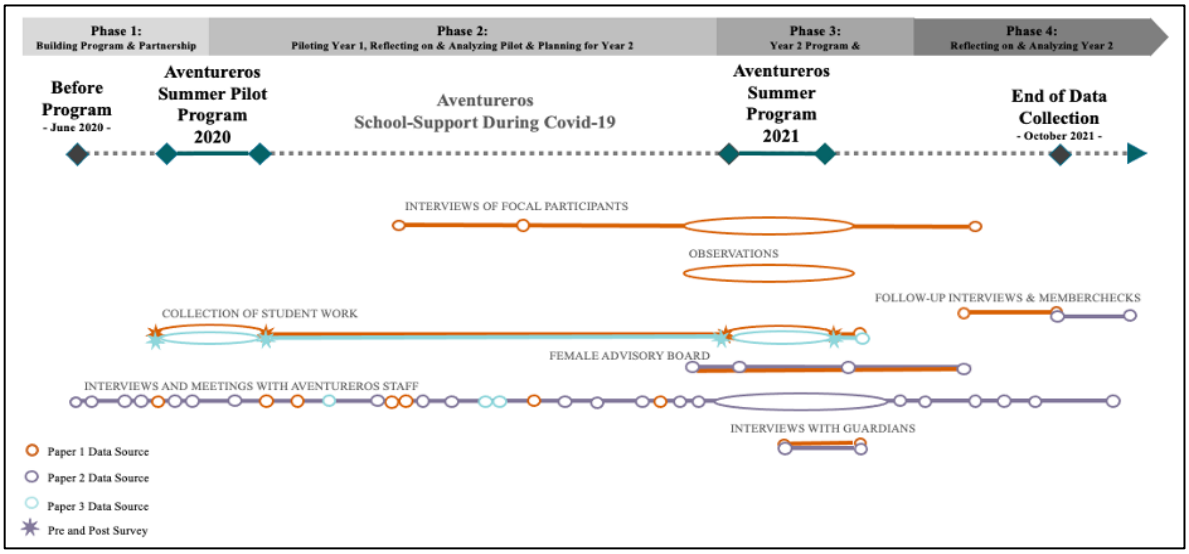


Figure A2. Youth Plastics Research Activities and Milestones

Date	Inquiry Research Activities
October 2020	-Week of plastic pollution lessons—guest teachers
February 2021	-Week of composting lessons
March 2021	-Basur-a-thon: a month of trash pick-up to raise money for whale trip
April 2021	-Dump project lessons
May 2021	-Week of marine plastic pollution lessons -Develop microplastic protocol video to share with guests -Make and share media awareness graphics -Paper models to show: How plastic pollution is impacting the bay? -Protocol is expanded to collect meso and macro plastics on transect and beach sites -Practice new protocol (samples 1-3), including on Coronado Island

June 2021	-Setup and inventory equipment for summer research teams **-1-day plastic survey cycle with visiting families and kids** • Explain project, protocol, & importance • Survey beach close to VSFS and log data • Swim, snorkel & play -Create protocols for, build and set-out rocky shore trap -Create community bulletin board to share project updates with station staff and visitors
July 2021	**-2-day plastic survey cycle with visiting graduate class I** • Explain project, protocol, importance, learnings • Survey beaches accessible by van and log data • Swim, snorkel & play • Survey beaches accessible by boat and log data • Swim, snorkel, observe & explore -Tiempo libre (short lesson & swim time at station) -CONANP lecture on marine pollution, Quemado trash sort & night party at La Gringa to celebrate work -Tiempo libre (short lesson & swim time at station) -Retrieve rocky shore trap and log data **-2-day plastic survey cycle with visiting graduate class II** • Explain project, protocol, importance, learnings • Survey beaches accessible by van and log data • Swim, snorkel & play • Survey beaches accessible by boat and log data • Swim, snorkel, observe & explore -Build and test LADI trawler, discuss future use

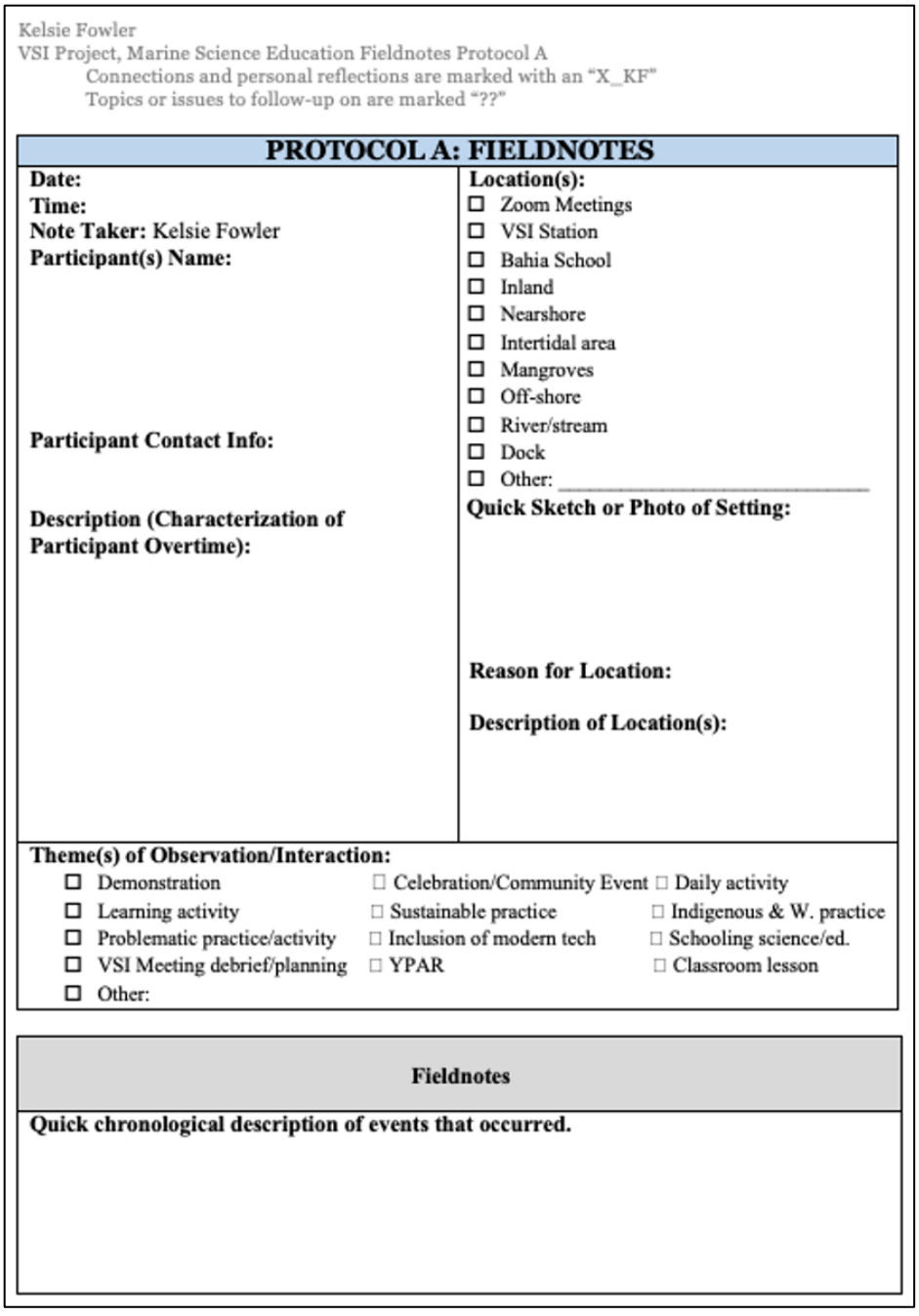
August 2021	-Social media competition to increase awareness of local plastic pollution **-2-day plastic survey cycle with visiting graduate class III** • Explain project, protocol, importance, learnings • Survey beaches accessible by van and log data • Swim, snorkel & play • Survey beaches accessible by boat and log data • Swim, snorkel, observe & explore -Birthday party celebrating Alejandro -Tiempo libre (short lesson & swim time at station) -Set-out rocky shore trap -Birthday party celebrating Brillith -Interviews about field experiences and project -Boat day celebrating research progress— "Agua Mala!" scenario **-2-day plastic survey cycle with visiting graduate class IV** • Explain project, protocol, importance, learnings • Survey beaches accessible by van and log data • Swim, snorkel & play • Survey beaches accessible by boat and log data • Swim, snorkel, observe & explore
September 2021	-Community cigarette collection project started
October 2021	-Data entered to ArcGIS mapping tool -Community flier created summarizing findings kids and staff thought were most important -Debrief of project
November 2021	-Data formally submitted to The Big Microplastic Survey -Participation in town's conservation week—youth win award!

December 2021	-Map animal sightings, natures' wonders & abundance in the bay to reclaim these waters for hope
February 2021	-Apply for NOAA Marine Debris Prevention grant to apply project findings and implications in community
September 2022 – February 2024	-NOAA Marine Debris Prevention grant received • Youth fieldwork continues at a smaller scale and the focus becomes leading plastic prevention work and community education/research • Beach and desert surveys and clean-ups each month • Community education events each month • Development of community science lab • Development of community waste management system

Appendix B

Study Tools and Protocols

Figure B1. Image of Fieldnote Protocol that became a Google Form that I completed using field jottings and other artifacts after each major study event/activity



Kelsie Fowler
VSI Project, Marine Science Education Fieldnotes Protocol A
Connections and personal reflections are marked with an "X_KF"
Topics or issues to follow-up on are marked "??"

PROTOCOL A: FIELDNOTES

Date:
Time:
Note Taker: Kelsie Fowler
Participant(s) Name:

Participant Contact Info:

Description (Characterization of Participant Overtime):

Location(s):
- ☐ Zoom Meetings
- ☐ VSI Station
- ☐ Bahia School
- ☐ Inland
- ☐ Nearshore
- ☐ Intertidal area
- ☐ Mangroves
- ☐ Off-shore
- ☐ River/stream
- ☐ Dock
- ☐ Other: _____

Quick Sketch or Photo of Setting:

Reason for Location:

Description of Location(s):

Theme(s) of Observation/Interaction:

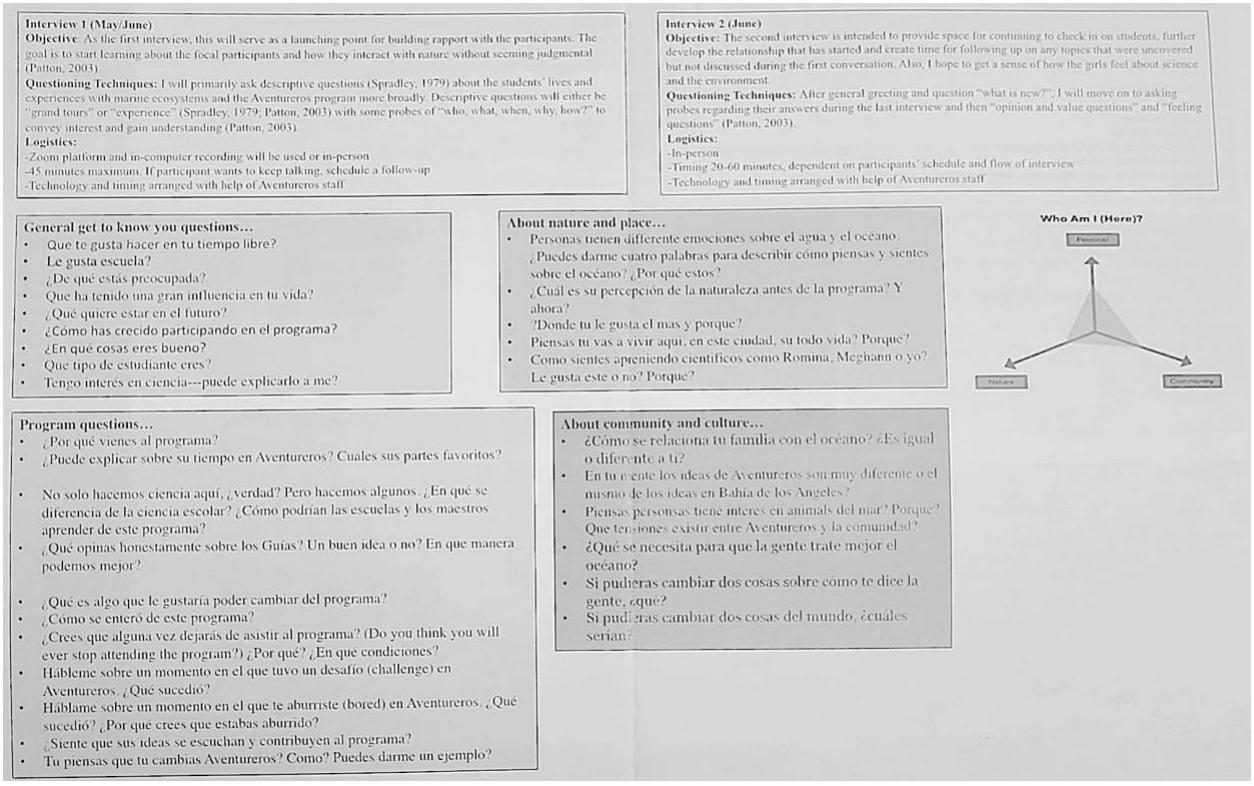
☐ Demonstration	☐ Celebration/Community Event	☐ Daily activity
☐ Learning activity	☐ Sustainable practice	☐ Indigenous & W. practice
☐ Problematic practice/activity	☐ Inclusion of modern tech	☐ Schooling science/ed.
☐ VSI Meeting debrief/planning	☐ YPAR	☐ Classroom lesson
☐ Other:		

Fieldnotes

Quick chronological description of events that occurred.

Sketches or Episodes for Narrative from the Observation/Interaction • Details (important quotes, names and definitions, processes, specific examples or even photographs of a process or product) of the observation that seem to align within important themes or highlight new themes of the research project.
(1)
(2)
(+) Add more rows for different sketches/episodes as needed.
Summary Commentary:
Any Follow-Up Questions or Information Needed:

Figure B2. Image of Interview Notetaker that I used throughout interview series with Aventureros



Interview 1 (May/June)
Objective: As the first interview, this will serve as a launching point for building rapport with the participants. The goal is to start learning about the focal participants and how they interact with nature without seeming judgmental (Patton, 2003).
Questioning Techniques: I will primarily ask descriptive questions (Spradley, 1979) about the students' lives and experiences with marine ecosystems and the Aventureros program more broadly. Descriptive questions will either be "grand tours" or "experience" (Spradley, 1979; Patton, 2003) with some probes of "who, what, when, why, how?" to convey interest and gain understanding (Patton, 2003).
Logistics:
-Zoom platform and in-computer recording will be used or in-person
-45 minutes maximum. If participant wants to keep talking, schedule a follow-up
-Technology and timing arranged with help of Aventureros staff

Interview 2 (June)
Objective: The second interview is intended to provide space for continuing to check in on students, further develop the relationship that has started and create time for following up on any topics that were uncovered but not discussed during the first conversation. Also, I hope to get a sense of how the girls feel about science and the environment.
Questioning Techniques: After general greeting and question "what is new?", I will move on to asking probes regarding their answers during the last interview and then "opinion and value questions" and "feeling questions" (Patton, 2003).
Logistics:
-In-person
-Timing 20-60 minutes, dependent on participants' schedule and flow of interview
-Technology and timing arranged with help of Aventureros staff

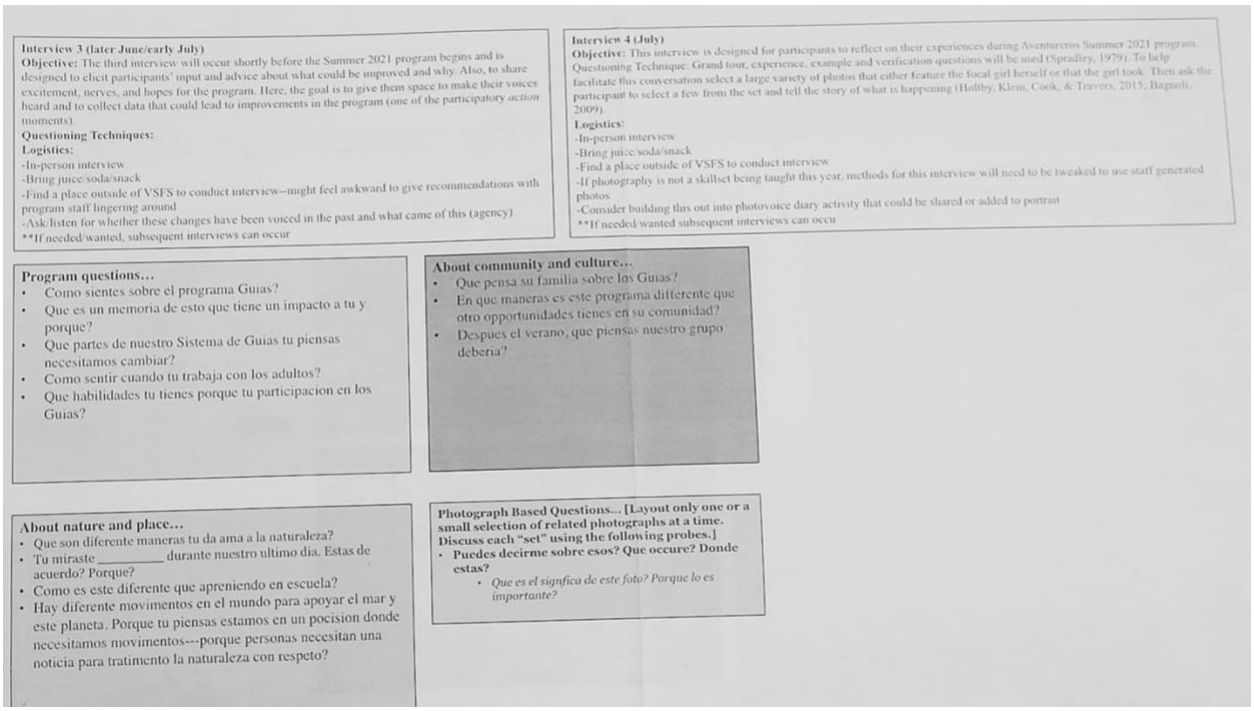
General get to know you questions…
- Que te gusta hacer en tu tiempo libre?
- Le gusta escuela?
- ¿De qué estás preocupada?
- Que ha tenido una gran influencia en tu vida?
- ¿Qué quiere estar en el futuro?
- ¿Cómo has crecido participando en el programa?
- ¿En qué cosas eres bueno?
- Que tipo de estudiante eres?
- Tengo interés en ciencia---puede explicarlo a me?

About nature and place…
- Personas tienen different emociones sobre el agua y el océano. ¿Puedes darme cuatro palabras para describir cómo piensas y sientes sobre el océano? ¿Por qué estos?
- ¿Cuál es su percepción de la naturaleza antes de la programa? Y ahora?
- ?Donde tu le gusta el mas y porque?
- Piensas tu vas a vivir aqui, en este ciudad, su todo vida? Porque?
- Como sientes apreniendo cientificos como Romina, Meghann o yo? Le gusta este o no? Porque?

Who Am I (Here)?
Personal
Nature
Community

Program questions…
- ¿Por qué vienes al programa?
- ¿Puede explicar sobre su tiempo en Aventureros? Cuales sus partes favoritos?
- No solo hacemos ciencia aquí, ¿verdad? Pero hacemos algunos. ¿En qué se diferencia de la ciencia escolar? ¿Cómo podrían las escuelas y los maestros aprender de este programa?
- ¿Qué opinas honestamente sobre los Guías? Un buen idea o no? En que manera podemos mejor?
- ¿Qué es algo que le gustaría poder cambiar del programa?
- ¿Cómo se enteró de este programa?
- ¿Crees que alguna vez dejarás de asistir al programa? (Do you think you will ever stop attending the program?) ¿Por qué? ¿En qué condiciones?
- Háblame sobre un momento en el que tuvo un desafío (challenge) en Aventureros. ¿Qué sucedió?
- Háblame sobre un momento en el que te aburriste (bored) en Aventureros. ¿Qué sucedió? ¿Por qué crees que estabas aburrido?
- ¿Siente que sus ideas se escuchan y contribuyen al programa?
- Tu piensas que tu cambias Aventureros? Como? Puedes darme un ejemplo?

About community and culture…
- ¿Cómo se relaciona tu familia con el océano? ¿Es igual o diferente a ti?
- En tu mente los ideas de Aventureros son muy diferente o el mismo de los ideas en Bahía de los Angeles?
- Piensas personsas tiene interés en animals del mar? Porque? Que tensiones existir entre Aventureros y la comunidad?
- ¿Qué se necesita para que la gente trate mejor el océano?
- Si pudieras cambiar dos cosas sobre cómo te dice la gente, ¿qué?
- Si pudieras cambiar dos cosas del mundo, ¿cuáles serían?



Interview 3 (later June/early July)
Objective: The third interview will occur shortly before the Summer 2021 program begins and is designed to elicit participants' input and advice about what could be improved and why. Also, to share excitement, nerves, and hopes for the program. Here, the goal is to give them space to make their voices heard and to collect data that could lead to improvements in the program (one of the participatory *action* moments).
Questioning Techniques:
Logistics:
-In-person interview
-Bring juice/soda/snack
-Find a place outside of VSFS to conduct interview--might feel awkward to give recommendations with program staff lingering around
-Ask/listen for whether these changes have been voiced in the past and what came of this (agency)
**If needed/wanted, subsequent interviews can occur

Interview 4 (July)
Objective: This interview is designed for participants to reflect on their experiences during Aventureros Summer 2021 program. Questioning Technique: Grand tour, experience, example and verification questions will be used (Spradley, 1979). To help facilitate this conversation select a large variety of photos that either feature the focal girl herself or that the girl took. Then ask the participant to select a few from the set and tell the story of what is happening (Holtby, Klein, Cook, & Travers, 2015; Bagnoli, 2009).
Logistics:
-In-person interview
-Bring juice/soda/snack
-Find a place outside of VSFS to conduct interview
-If photography is not a skillset being taught this year, methods for this interview will need to be tweaked to use staff generated photos
-Consider building this out into photovoice diary activity that could be shared or added to portrait
**If needed/wanted subsequent interviews can occu

Program questions…
- Como sientes sobre el programa Guias?
- Que es un memoria de esto que tiene un impacto a tu y porque?
- Que partes de nuestro Sistema de Guias tu piensas necesitamos cambiar?
- Como sentir cuando tu trabaja con los adultos?
- Que habilidades tu tienes porque tu participacion en los Guias?

About community and culture…
- Que pensa su familia sobre los Guias?
- En que maneras es este programa differente que otro opportunidades tienes en su comunidad?
- Despues el verano, que piensas nuestro grupo deberia?

About nature and place…
- Que son diferente maneras tu da ama a la naturaleza?
- Tu miraste _____ durante nuestro ultimo dia. Estas de acuerdo? Porque?
- Como es este diferente que apreniendo en escuela?
- Hay diferente movimentos en el mundo para apoyar el mar y este planeta. Porque tu piensas estamos en un pocision donde necesitamos movimentos---porque personas necesitan una noticia para tratimento la naturaleza con respeto?

Photograph Based Questions… [Layout only one or a small selection of related photographs at a time. Discuss each "set" using the following probes.]
- **Puedes decirme sobre esos? Que occure? Donde estas?**
  - *Que es el signfica de este foto? Porque lo es importante?*

Figure B3. Image of Personal Journal prompts I referenced as needed when journaling each evening

PROTOCOL: Reflexivity Personal Journal Prompts

For whom? For what? How do I/we need to be moving forward?

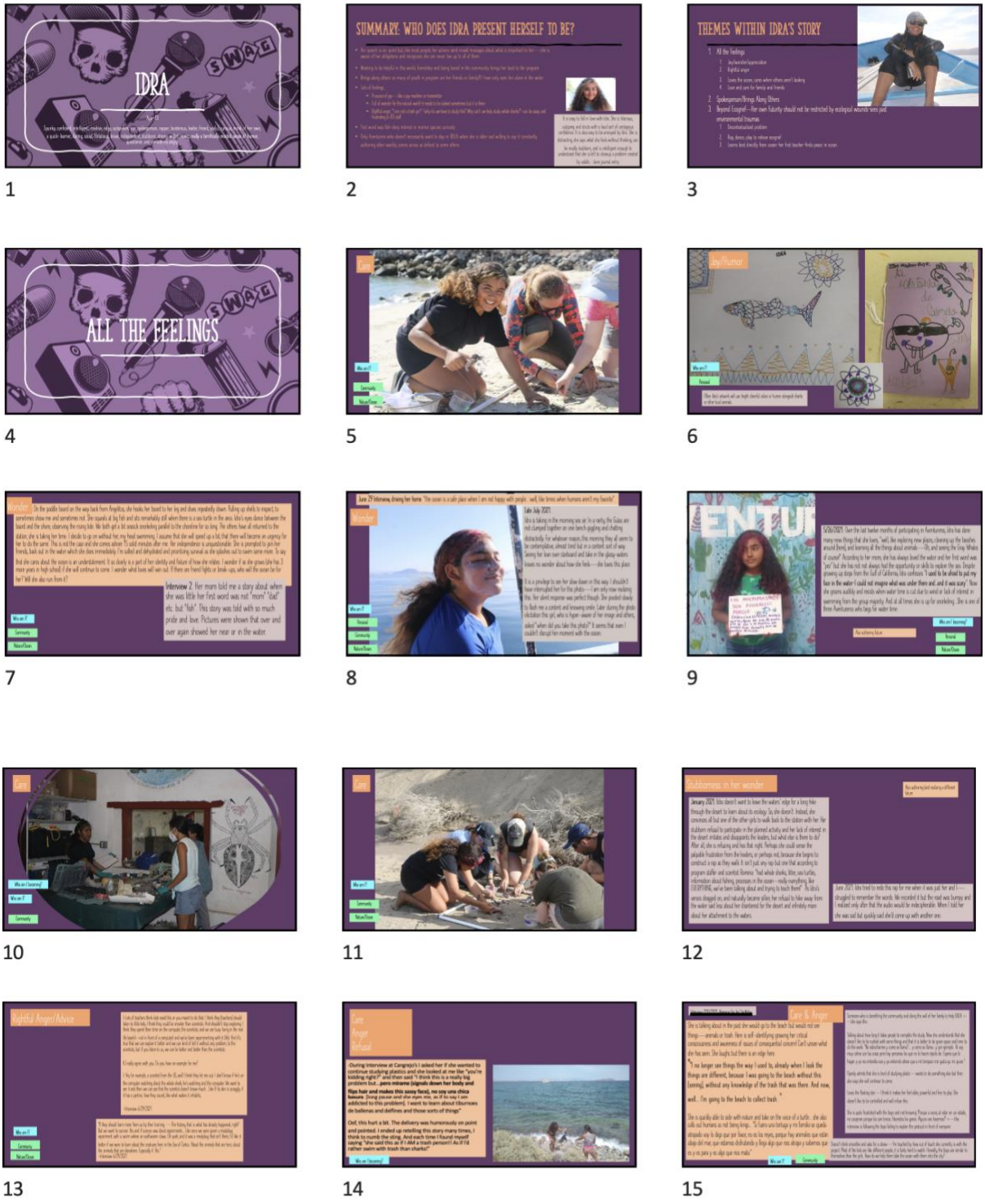
Focal girls	**Aventureros and/or EE and/or VSI**
BLDA Community	**Power, identity, positionality and influence**
Methodology---Motherhood during a critical ethnography	**Marine Sciences**
School Science	**Personal learnings (they are all personal, but ya know?)**

1. **Date.**
2. **Who or what is prompting this entry and why?**
3. **What new thoughts or questions are surfacing about the program? Focal girls? AGuías? VSI staff? Community? Etc.**
4. **How is my own positionality or influence impacting what is happening? Is this okay? How do I need to be moving forward?**

Appendix C

Focal Girl Portfolios Developed in Coding & Analysis Process

Figure C. Example participant portfolio



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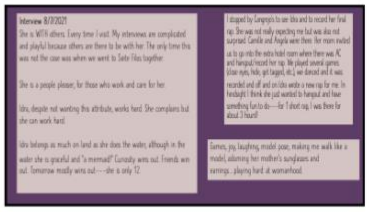

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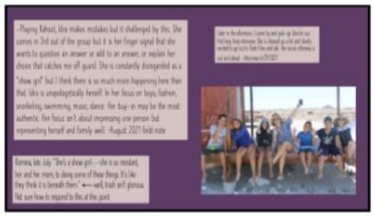

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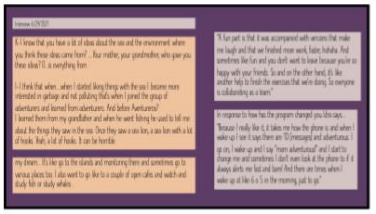

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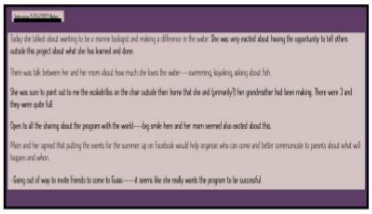

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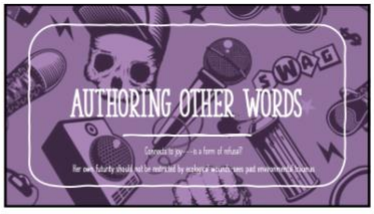

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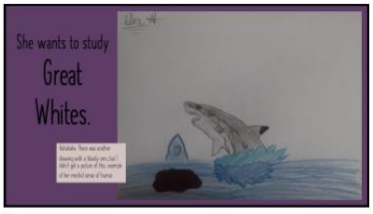

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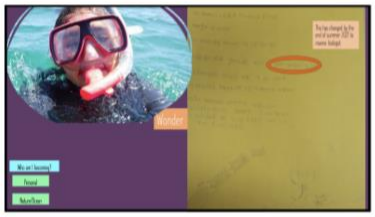

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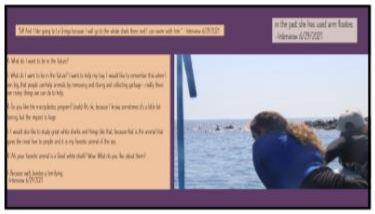

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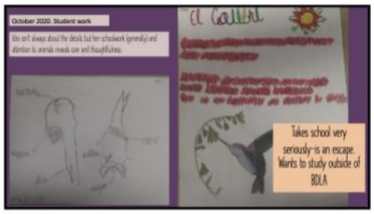

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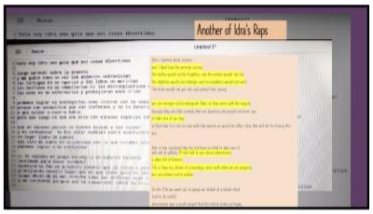

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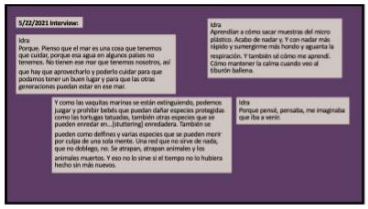

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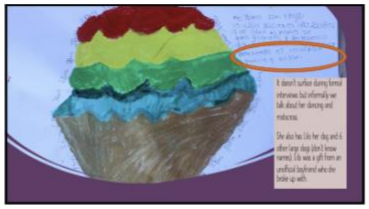

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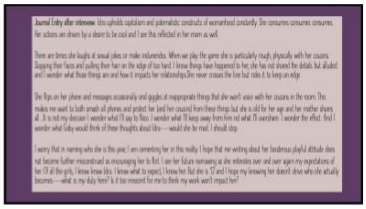

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Appendix D

Early Brainstorming of Multilogics used to inform Socio-Ecological Minding Analysis

This is a resource I made for myself that lists the questions and ideas I tried to attend to while conducting data analysis and writing this paper to take a multilogics approach. As these are my own notes, they are incomplete and there are other theories and ideas I pulled upon as the study progressed, but these were the multilogics lenses that grounded this article from the onset.

1. **What relations and obligations do we need to recognize and care about?** Doing inquiry should necessitate unpacking the project holistically and our individual impact on families, local and global human communities, the more-than-humans and other-than-being beings (PERSONS, Practice in Kinship series). As members of multiple communities, participants of inquiries juggle the varied goals, commitments, duties to and hopes that come from being in these relationships (Haraway, 2016; Kinship Series, 2021)—and recognizing these inconsistencies, tensions and varied obligations are worthy of reflection. When we are concerned with being good relatives and holding up our obligations to them, we more deeply consider what cultural and ecological human and biotic diversity needs to be conserved (Grunewald, 2003, p. 10)—it becomes less about undershooting death or extreme illness thresholds and more about attending to others' well-being (Liboiron, 2021) and livingness (Haraway, 2016).

2. **What other perspectives, including multispecies and other-than-being beings, should be considered?** For example, practicing seeing the world through more-than-human perspective on relationality, rights, sustainability and environmental education/wellness should occur regularly (Griffiths & Murray, 2017), as it builds understanding of a shared life and planet and develops respect for all beings in the universe (Zidney et al., 2020; Kohn, 2013; The Kinship Series, 2021; Gumbs, 2020). Be sure to think about rights of nature and multispecies and how this compares to extractive

ideas/logics–even just visiting a place may be harmful in ways that are difficult to trace (Bani Amor, 2021).

3. **What has been overlooked and how are we attending to these "neglected things"?** While unglamorous, and often viewed as a nuisance in science, learning to hold space for "neglected things" in our inquiry projects supports long-term collective conscious building. Neglected things (Puig de la Bellacasa, 2017) can be objects, protocols, permits, habits, other-than-being beings, even people—really anything that has been forgotten or cast aside. To give attention and care to these largely "neglected things", overtime teaches us not to neglect in the first place and live with greater ecological gratitude and intentionality (Wall Kimmerer, 2013; The Kinship Series, 2021).

4. **How are our actions refusals of harm and violence historically cast by dominant science?** Consider methods and protocols themselves as important sites of refusal and a (re)writing of how science can be done (Wölfle Hazard, 2022; Liboiron, 2021; Harding, 2008). There are IRBs and consent forms, suggestions on methodological frames but look at power structures within research (Madison, 2020). Don't be afraid to revise thinking, work, protocols (Laymon, 2020) and to create or stay with trouble of doing things unexpectedly (Haraway, 2016).