Introduction: Global climate change is altering the transmission and impact of pathogens in the ocean. Many marine host-pathogen systems are poorly understood, and even less is known about how global climate change will affect the specific mechanisms of these systems[1]. The "Climate Variability Hypothesis," an extension of the metabolic theory of ecology, proposes that extreme climate events are advantageous for parasites because they are smaller and have faster metabolisms than their hosts; thus, they can acclimatize to extreme environmental changes more quickly[2]. Most predictions of host-parasite responses to climate change have focused on mean temperature changes (which may be modest), yet there is strong evidence suggesting that the increasing frequency of climatic extremes can greatly alter these predictions[2].

Although there have been extensive studies on pathogens of some species (e.g., corals, oysters, abalone, some fish, and marine mammals), particularly those harvested or cultured for human consumption, others remain largely understudied[1]. This is surprising, considering the substantial contribution of marine parasites to ecosystem biomass and diversity[3,4]. It is often assumed that pathogenic parasites will experience greater fitness in a warming world, but parasite-host systems are more delicate and complex than this generalization implies[5]. In particular, castrating parasite survival strategies are so extreme that they reroute a host's energy allocation away from its own reproduction, driving host fitness to zero[6]. This leads to intense competition between hosts and parasites, which has strong implications for ecosystem structure[6].
Objective: My objective is to discern how climate change-driven temperature extremes affect marine host-parasite systems. To achieve this, I will use stable isotope analysis to study changes in nutritional interactions between two trematode-snail systems. Two Pacific snail species of the family Cerithiidae, *Cerithium moniliferum* and *Cerithidea californica*, both contain castrating parasites from the same family (Heterophyidae), but are found in tropical and temperate regions, respectively[7,8]. **Hypotheses**: **(1) Parasite discrimination over host tissue**: The $\delta^{13}C$ and $\delta^{15}N$ values of a parasite relative to its targeted host tissue will reflect a difference of one trophic level. **(2) Extreme climate conditions**: The host-parasite systems will experience higher infection intensity and faster nutrient turnover in response to variable temperature increases than to mean temperature increases. **(3) Temperate vs. tropical comparison**: Tropical species will be more susceptible to absolute changes in temperature in comparison to temperate species because they experience climates that are consistently less variable than temperate marine habitats[2].
Test of Hypotheses: (1) In previous stable isotopic assessments of parasite trophic status, no clear patterns have emerged of host-parasite *discrimination*, which is defined as the difference in their isotopic signatures relative to the host tissues on which they are feeding[9]. Because lighter atoms react more quickly in metabolic reactions, organisms tend to readily excrete the lighter isotopes, and their tissues therefore become *enriched*, or have more of the heavy isotopes (in this case, ^{13}C and ^{15}N), than the foods they consume[10]; this trophic difference in isotopic signatures between an animal's tissues and its food is called *discrimination*. To test this hypothesis, I will determine the extent to which trematodes reroute host nutrients towards their own development, and which host tissues they target for nutrient acquisition. Snails from the wild have variable isotopic signatures, so I will raise uninfected snails on a known diet to establish a population with a known isotopic signature. This will feature diatoms grown in sterilized f/2 seawater medium and isotopically-labeled C ($NaH^{13}CO_3$) and N ($Na^{15}NO_2$ and $^{15}NH_4{}^{15}NO_3$) sources. Once the snails are isotopically stable and have incorporated this tracer, their tissues will serve as a baseline diet for the parasites. I will then infect the snails and in a time series analyze the $\delta^{13}C$ and $\delta^{15}N$ signatures of various host tissues and the parasites to examine how long it takes the trematodes to match the isotopic signature of their diet, and their discrimination above known

host tissues[11]. The discrimination in $\delta^{13}C$ for amino acids (AAs) can be used conservatively to track diet, as it is largely driven by whether they are essential or nonessential. I will analyze the $\delta^{13}C$ and $\delta^{15}N$ of essential AAs in the parasite[10]. As the nonessential AAs generally show more variability in discrimination, I will analyze their isotopic signatures to further elucidate the dietary source of nutrients in the parasite[10]. **(2&3):** I will again raise both snail species on diatoms of known isotopic signatures, and infect them with trematodes. I will then divide each group into 3 temperature treatments: a control, stable temperature similar to the snails' respective field sites; a stable temperature 2.5°C warmer than the control, which is between low- and high-emission climate change models[12]; and this +2.5°C condition with a further ±3°C variation. I will measure changes in infection intensity, gonadal consumption rate, host size, isotope ratios of gonadal and parasite tissue, and isotopic turnover rate in the parasite's AAs.

Expected results: **1)** I expect that isotopic ratios of parasitic castrators will show specificity for the host tissue targeted for feeding. A parasite that feeds solely on a specific organ (i.e. gonads) should be isotopically enriched above that specific host organ, as opposed to another organ (e.g., liver), which can have a different isotopic signature. **2)** Infection intensity will be highest, parasite turnover will be quickest, and the rate of gonadal consumption will be highest in the highly variable temperature treatment as the parasites acclimatize to temperature changes faster than their hosts. **3)** I predict that the tropical species will experience greater changes in parasite nutrient acquisition and infection intensity than the temperate species.

Intellectual Merit: Marine parasites contribute greatly to ecosystem diversity[3], and castrating trematodes can substantially reduce host density and change host life histories[6]. Understanding the mechanisms of parasitic castration (specifically, the nutrient rerouting from host reproduction to parasite growth) is necessary to distinguish castration from the many other parasite strategies that result in reduced host fitness and abundance[6]. Very little work has been done to combine the effects of climate variability and the application of the metabolic theory of ecology on marine disease systems, despite the growing number of calls to do so[1,13,14] and the devastating ecosystem shifts caused by some marine parasites (e.g. massive die-offs of Chesapeake Bay oysters infected with *Perkinsus marinus*, the range for which has expanded likely due to warming ocean temperature[15]). My research will fill this gap by providing a better understanding of the mechanisms of castration and the effects of climate variability on their function.

Broader Impacts: Engaging students in understanding anthropogenic effects on ecosystems is the first step toward sparking long-term interest mitigating these changes. I will be joining an outreach project at Crystal Cove State Park and teaching local middle school students to use underwater cameras to collect biodiversity data inside and outside a marine protected area. I will also fully include interested students in the analysis, interpretation, and presentation of the data. I will also join an established partnership with Valencia High School, which is composed mostly of underrepresented groups. I will engage general biology students in hands-on science by aiding lesson planning, and helping students formulate their own hypotheses and experimental designs. I will increase participation in the sciences by inviting students from the UCI Minority Science Program –young female scientists, in particular– to engage in these activities and in my research.

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