Prioritizing *Pycnopodia*: Policy recommendations to combat Sea Star Wasting Syndrome amongst Sunflower sea star populations in the Pacific Northwest

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The Sunflower sea star (*Pycnopodia helianthoides*) is a keystone species within Pacific Northwest marine habitats and threats to its livelihood threaten the vitality and ecological order of Pacific Northwest marine ecosystems as a whole. Sunflower sea stars are carnivorous scavengers whose unmitigated appetite helps control local urchin populations (Aquino et al., 2020; Gudenkauf, B. M., & Hewson, I., 2015). The Purple Sea Urchin (*Strongylocentrotus purpuratus)* is one species in particular that is favored by the Sunflower sea star (Aquino et al., 2020; Gudenkauf, B. M., & Hewson, I., 2015). If local urchin populations such as *Strongylocentrotus purpuratus* are not mitigated by Sunflower sea stars, the impacts on local marine flora are catastrophic due to the urchin's overconsumption of marine flora. *Strongylocentrotus purpuratus* consumes a significant amount of brown algae such as Bull Kelp (*Nereocystis luetkeana)* (Aquino et al., 2020; Gudenkauf, B. M., & Hewson, I., 2015). Bull Kelp forests serve as a habitat for a variety of local animals such as the Dungeness crab (*Metacarcinus magister),* Kelp crab (*Pugettia productus)* and Brown rockfish (*Sebastes auriculatus*) (Rogers-Bennett & Catton, 2019; Williams et al., 2021) . The collapse of a kelp forest due to unmitigated urchin consumption leads to a myriad of disastrous ecological consequences (Rogers-Bennett & Catton, 2019; Williams et al., 2021). *Pycnopodia helianthoides* plays an unquestionable role in the health and vitality of local marine habitats. Local habitats have intermittently experienced the disastrous effects of *Pycnopodia helianthoides* population declines due to the ongoing and progressively more frequent outbreaks of Sea Star Wasting Disease in Washington state. This paper seeks to analyze the pathology behind the illness within populations of *Pycnopodia helianthoides* and provide policy recommendations based on those findings. The first half of the paper delves into what is known about the epidemiology and

pathogenesis of Sea Star Wasting Disease while the second half of the paper offers a two-pronged policy solution to combat the illness..

Sea Star Wasting Disease in *Pycnopodia helianthoides*

Sea Star Wasting Disease (SSWD) is a phenomenon that has been documented within the Pacific Northwest since the 1970s (Aquino et al., 2020; Gudenkauf, B. M., & Hewson, I., 2015). However, the outbreaks within Washington state and throughout the Pacific Northwest have become more frequent and severe since it was first documented in 1972 (Aquino et al., 2020; Gudenkauf, B. M., & Hewson, I., 2015). The outbreaks from 2013 onward have been especially severe within Washington state (Aquino et al., 2020; Gudenkauf, B. M., & Hewson, I., 2015). Sea Star Wasting Disease is a pathogen with multiple stages that eventually culminate in the death of the affected star (Aquino et al., 2020; Gudenkauf, B. M., & Hewson, I., 2015; National Park Service, 2024). In its initial stages, Sea Star Wasting Disease causes lethargy and the affected stars refrain from eating (Aquino et al., 2020; Gudenkauf, B. M., & Hewson, I., 2015; National Park Service, 2024). Affected stars later develop white lesions on their bodies and the tissue around the lesions disintegrates completely (Aquino et al., 2020; Gudenkauf, B. M., & Hewson, I., 2015; National Park Service, 2024). Eventually, the lesions become deep enough to reach the star's water vascular system and the affected star is no longer able to move or maintain circulation within that part of its body (Aquino et al., 2020; Gudenkauf, B. M., & Hewson, I., 2015; National Park Service, 2024). The tissue decay becomes so significant that the impacted arms disintegrate completely and fall off of the body of the sea star (Aquino et al., 2020; Gudenkauf, B. M., & Hewson, I., 2015; National Park Service, 2024).

Sea Star Wasting Disease affects over a dozen different types of sea stars that exist within the region including *Pisaster ochraceous*, *Pisaster brevispinus*, *Evasterias troschelii* and

Pycnopodia helianthoides (Aquino et al., 2020; Gudenkauf, B. M., & Hewson, I., 2015;McCracken et al., 2023). It has also caused devastation amongst local populations of *Pisaster ochracerous* (also known as the Purple or Ochre star) and *Pisaster brevispinus* (Pink Spiny sea star). However, *Pycnopodia helianthoides* has one of the highest mortality rates amongst affected species (Gravem, et al, 2021; Konar, 2019; McCracken et al., 2023). It is believed that Sea Star Wasting Disease has decimated ninety percent of the Sunflower sea star population (Gravem, et al, 2021; Konar, 2019; McCracken et al., 2023). The Sunflower sea star is a prime candidate for a higher degree of support due to its high mortality rate and the important role that it plays in local ecosystems.

Sea Star Wasting Disease Pathogenesises

The exact cause of Sea Star Wasting disease is unknown, however there has been some research that has been done to determine the cause of the illness (Konar, 2019; McCracken et al., 2023). The scientific community has determined that the most likely cause of the disease is a bacteria, however the exact species of bacteria has yet to be determined due to the fact that the research is ongoing (Konar, 201).9; McCracken et al., 2023). Some research has pointed toward the viral agent densovirus playing a role (Hewson et al., 2014; Hewson et al., 2024; Jackson, 2020). More recent studies have moved away from this theory, but the results remain inconclusive (Konar, 2019; Hewson et al. 2024; McCracken et al., 2023). The exact pathogen that causes Sea Star Wasting Disease is currently unknown (Hewson et al., 2014; Hewson et al., 2024; Jackson, 2020; Konar, 2019; McCracken et al., 2023).

There has been progress made with regards to the manner in which the disease progresses within the sea star (Konar, 2019; McCracken et al., 2023). The initial onset of the disease is instigated by changes in the environment which allow the pathogen that causes Sea Star Wasting

Disease to reproduce in higher numbers and grow colonies on the epidermis of the star (Konar, 2019; McCracken et al., 2023). This pathogen proliferation makes it impossible for the affected sea stars to breathe (Konar, 2019; McCracken et al., 2023). The gills of all stars are known as papulae and are found on the top part of their epidermis (Konar, 2019; McCracken et al., 2023). These papulae connect to the body cavity (known as the coelom) and facilitate gas exchange between the star's body and the surrounding environment (Konar, 2019; McCracken et al., 2023). A typical sea star has thousands of papulae on its body and having a small number of these temporarily covered is unlikely to significantly damage their health. However, during a bacteria or virus bloom, the entire surface of the star is covered and they are unable to take in enough oxygen to survive (Konar, 2019; McCracken et al., 2023). This causes them to suffocate and decay and the decaying matter from their bodies proliferates throughout the ocean and spreads the disease (Konar, 2019; McCracken et al., 2023). Colder temperatures mitigate the spread of the pathogen that causes Sea Star Wasting Disease due to the fact that in colder temperatures they are not able to proliferate to a level that obstructs the respiration of affected stars. A small population of the pathogen appears to not be deadly for the star and it only becomes virulent when it experiences a bloom and is able to cover the upper surface of the star where the papulae are located (Konar, 2019; McCracken et al., 2023).

Policy Considerations for Sea Star Wasting Disease

In the Pacific Northwest, there are two policy considerations that must be taken into account in relation to Sea Star Wasting Disease: 1. Further study of the disease itself that will lead to a more comprehensive understanding of the specific pathogen that causes it, the complete epidemiology of the disease and the environmental conditions that allow it to flourish. 2. A greater degree of policy action to combat climate change due to the fact that water temperature

appears to be the most prominent environmental factor that contributes to the proliferation of Sea Star Wasting Disease amongst *Pycnopodia helianthoides* and other sea star populations.

Research Needs Related to Sea Star Wasting Disease

One of the primary issues surrounding policy creation for combating Sea Star Wasting Disease in *Pycnopodia helianthoides* is that the exact cause of the disease is unknown. The public is unlikely to trust a policy solution if the issue that it is trying to address is not fully understood. A policy solution that does not clearly articulate the cause of the disease will also be vulnerable to propaganda campaigns from industry due to the fact that any policy that combats global warming will undoubtedly subject companies that utilize large amounts of fossil fuels to stricter environmental regulations. A historical example of this would be the campaigns by fossil fuel companies such as ExxonMobil (Guardian News and Media, 2021). When climate change was first encountered by scientists in the 1970s, fossil fuel companies were aware of its existence and subjected the public to a series of targeted advertisements that questioned the existence and validity of climate change (Guardian News and Media, 2021). Multiple fossil fuel companies accused climate scientists of being “unreliable” and “obsessed with doomsdays” (Guardian News and Media, 2021). ExxonMobil in particular has released advertisements with titles such as “Lies They Tell Our Children” and “Real Climate Solutions Won’t Happen Without Natural Gas and Oil” (Guardian News and Media, 2021). These campaigns continued on through the 1980s, 1990s, and continue on to this day (Guardian News and Media, 2021). Environmental regulations harm the profit margins of these large corporations and upset their shareholders. Therefore, it is vital that interested stakeholders invest in further research to help determine the cause of the disease and the environmental factors that propel its proliferation. The fossil fuel industry in particular is likely to question any policy that might compel them to new regulations.

Task Force Design and Implementation

In order to conduct said research, a formal task force will have to be implemented. The Washington State Department of Fish and Wildlife will designate research funding for Sea Star Wasting Disease in *Pycnopodia helianthoides* and local state and city governments will also contribute to this project. The task force will operate in multiple municipal areas throughout the state and local funding will be dependent upon the amount of task force work being done in those areas. Municipalities located near areas which have experienced a substantial decline in their *Pycnopodia helianthoides* populations will be more financially involved with it. This task force will also elicit funding from federal and non-profit sources. Grant applications for this project will stress the importance of *Pycnopodia helianthoides* as a keystone species within local marine ecosystems.

The task force will have two main priorities: 1. determine the exact cause of Sea Star Wasting Disease in *Pycnopodia helianthoides* including the primary pathogen(s) involved. 2. determine the environmental conditions that engender its proliferation in local marine environments. An independent review board will be appointed before the study commences and this body will make sure that all of the research that is being conducted is unbiased and accurate. Funding for said board will be included in the initial task force funding. The task force will be implemented and renewed on an annual basis until its stated objectives have been realized. Once the cause and environmental factors have been determined, the task force will either be dissolved or restructured to address related issues within the communities that it serves.

Climate Change Policy and Sea Star Wasting Disease

One environmental factor that has been found to contribute to Sea Star Wasting Disease in all major studies is ocean water temperature (Gudenkauf & Hewson, 2015; Konar et al., 2019;

McCracken et al., 2023). The temperature of the water in the ocean has been found to directly correlate with atmospheric land temperatures (Konar et al., 2019; McCracken et al., 2023; National Aeronautics and Space Administration, 2019). Therefore, more general efforts to combat global climate change would be relevant and appropriate to this cause. Washington state has already taken significant steps to combat climate change locally and globally including the 2021 Climate Commitment Act, State Agency Climate Leadership Act and the Ocean Acidification Blue Ribbon Panel (Climate Commitment Act, 2021; Washington State Department of Ecology, 2024). Many of the relevant aspects of these policies already concern the health of local marine ecosystems (Climate Commitment Act, 2021; Washington State Department of Ecology, 2024). The knowledge that arises from the actions of the task force on *Pycnopodia helianthoides* would be of greater service supplementing existing programs within Washington state rather than creating entirely new ones. However, the validity and necessity of Washington state's climate action programs is constantly being called into question by local industries that are adversely impacted by the programs' regulations such as the fossil fuel industry, the ecommerce industry along with other industries that require large amounts of fossil fuels to transport goods. More comprehensive knowledge about the impact of climate change on various types of local flora and fauna would lend more credence to these climate commitment programs and allow the public to better understand them.

One way in which *Pycnopodia helianthoides* research could help support the Climate Commitment Act is by potentially providing policymakers information that would favor lowering the emissions cap beyond what has already been proposed. If there is proven to be a negative correlation between Sunflower sea star populations and carbon emissions, one could argue that the emissions cap within Washington state should be lowered further to protect fragile

biomes within the state. If the task force can prove that the intermittent periods of warmer waters are allowing the bacteria that causes Sea Star Wasting Disease to bloom to uncontrollable levels, the situation could potentially be declared a greater emergency and emissions caps could be lowered accordingly.

Another way in which this research could be utilized in conjunction with the Climate Commitment Act is by having restoration projects related to the conservation of *Pycnopodia helianthoides* in the Climate Commitment Act allowance auctions (Climate Commitment Act, 2021; Washington State Department of Ecology, 2024). The task force could designate CCA-eligible projects and allow them to be in the general Climate Commitment Act auction that participating industries bid in (Climate Commitment Act, 2021; Washington State Department of Ecology, 2024) . These CCA-eligible projects would have applications beyond the conservation of *Pycnopodia helianthoides* due to the fact that they would lend themselves to the restoration of entire coastal habitats throughout Washington state. This would help a plethora of local animals that are not Sunflower sea stars and potentially revitalize entire pieces of the Washington state coastline.

The limits of CCA-based allowance auctions are that restoration programs themselves have a limited capacity to curb the mortality rate of Sunflower sea stars that succumb to Sea Star Wasting Disease. The main way in which they could potentially alleviate some of the damage from Sea Star Wasting Disease is by restoring parts of the shoreline and controlling the amount of freshwater runoff that is entering the Puget Sound in certain areas. Excess nutrients from freshwater runoff has been shown to contribute to outbreaks of Sea Star Wasting Disease, but it does not appear to be as strong of a factor in its proliferation as water temperature (Konar, 2019; McCracken et al., 2023).

The temperature of the ocean is not something that can easily be controlled through local restoration projects and requires a more comprehensive solution. The unfortunate thing about the world's saltwater bodies is that the majority of them are connected to one another and their temperature is heavily entwined with terrestrial weather patterns (National Aeronautics and Space Administration, 2024) . Local restoration projects cannot combat the overall trend of rising ocean temperatures more generally. However, larger-scale policy projects that curb the activities of industry in general and the fossil fuel industry in particular have the potential to be much more effective. The issue with any ailment that is caused by rising ocean temperatures is that the mechanics behind the temperature of the ocean are multifaceted and never limited to one geographic region of this planet (National Aeronautics and Space Administration, 2024). However, the wider the scale of the policy project, the more likely it is to be an effective change agent in relation to rising ocean temperatures. Future projects might want to consider utilizing the outcomes of this task force in conjunction with similar ones from other countries to support an international treaty of sorts.

Further Thoughts

The case of Sea Star Wasting Disease in *Pycnopodia helianthoides* is a multifaceted one that highlights the need for interdisciplinary approaches to ecological problems within the community. This particular issue needs policy support in order to ignite further inquiry on the exact agent that causes the disease and a complete overview of how it progresses within affected stars. It needs academic support from the scientific community in order to realize the necessary research. Once this action item is completed, it will need further policy support from relevant government authorities in order to enforce the necessary provisions to ultimately restore decimated populations of *Pycnopodia helianthoides* within Washington state.

While the case of Sea Star Wasting Disease amongst populations of *Pycnopodia helianthoides* appears to be a solitary one, it is actually one that is interconnected with the health of entire ecosystems within Washington state. Sea Star Wasting Disease impacts over twenty different species of sea stars within the Pacific Northwest (Burton et al., 2021; Konar et al., 2019; McCracken et al., 2023). Furthermore, the Sunflower sea star is a keystone species within Pacific Northwest ecosystems and it plays a critical role in consuming algae-eating herbivores. If Sunflower sea star populations go extinct, local brown and green algae populations will suffer due to an excess of herbivores such as Purple Sea Urchins within local oceans (Rogers-Bennett & Catton, 2019; Williams et al., 2021). Brown algae populations in particular are of great concern due to the fact that they provide a significant amount of habitat to local fauna and are nutrient dense photosynthesizers. Some types of brown algae such as Bull Kelp (*Nereocystis luetkeana*) are already struggling to maintain their populations and an increase in herbivores within their local ecosystems would most likely cause them to go extinct. Therefore, local environmental protection agencies should prioritize researching and eradicating Sea Star Wasting Disease within sea star populations in the Pacific Northwest.

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