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Public Cognitions and Emotions Associated with Sea Star Wasting Disease: An Exploratory Study in Oregon

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ABSTRACT

Biological research on sea star wasting disease (SSWD) is abundant, but there is little examining the human dimensions of this threat to marine environments. This article explored public emotions and cognitions (attitudes, norms) toward SSWD, and how these concepts are related to knowledge and risk perceptions associated with this threat. Data were from a survey of residents in the coastal and most populated regions of Oregon (n = 507). Respondents were grouped by their risk and knowledge, and shown five images depicting deteriorating conditions associated with SSWD, with questions measuring cognitions and emotions in response to each image. Knowledge about SSWD was quite low, and respondents perceived SSWD as a moderate risk to marine environments and a slight risk to themselves. As both knowledge and risk increased, awareness increased and emotions, attitudes, and norms became more negative, especially as SSWD conditions deteriorated. Implications and explanations of these findings were discussed.

KEYWORDS

Attitudes; emotions; knowledge; norms; perceived risk; sea star wasting disease

Introduction

Sea stars (i.e., starfish) are abundant and important predators in intertidal and abyssal plain areas of the ocean. In the Pacific Northwest of the United States (USA), for example, *Pisaster ochraceus* (i.e., purple or ochre sea star) is a keystone species that is an important indicator for the health of the intertidal zone (Menge et al., 2016). Sea star wasting disease (SSWD), however, threatens sea stars by causing them to develop lesions, lose arms, lose their ability to grip, and eventually die (Miner et al., 2018). SSWD is thought to be linked to a densovirus, but this has not been scientifically proven (Hewson et al., 2014). In the State of Oregon (USA), some of the worst outbreaks of SSWD started in 2013, causing substantial depletions across approximately 20 species of sea stars that changed marine communities (Fuess et al., 2015; Menge et al., 2016). For example, without sea stars in their typical abundance, sea urchins have few key predators and consume vast amounts of kelp, creating barren kelp beds (Shultz, 2020). Efforts to understand SSWD and these impacts include monitoring sea star populations and ecological consequences, and researching potential contributing factors (e.g., temperature, ocean pH; Menge et al., 2016).

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Relocation of some sea star species (e.g., the critically endangered sunflower sea star) into ecosystems not impacted by SSWD has been considered as one approach for managing this disease and conserving sea stars (Samayoa, 2020).

In addition to being a keystone species that regulates intertidal ecosystems such as tide pools, sea stars also provide services for humans (Millennium Ecosystem Assessment, 2005). Cultural ecosystem services are benefits to humans provided by ecosystems in general or species in particular (Fairchild et al., 2018; Millennium Ecosystem Assessment, 2005; Rees et al., 2010). Gould and Lincoln (2017) categorized several types of cultural ecosystem services and sea stars provide many of these, including recreation (e.g., hike to view sea stars in their natural habitat), aesthetic (e.g., appreciate the beauty of sea stars), artistic (e.g., produce art inspired by sea stars), heritage (e.g., traditional or ancestral uses of sea stars), bequest (value sea stars for future generations), and educational (e.g., learn about sea stars) services. Given these services and benefits that sea stars provide, it is important to understand public awareness, emotions, and cognitions (e.g., attitudes, norms) regarding threats to these species (e.g., SSWD), but few studies on these issues have been conducted (Lu, 2015). There is a need for more research on the human dimensions of this disease to inform both management and research. Exploring these topics is needed because it will improve understanding of what the public knows and thinks about SSWD, which may be useful for informing approaches for managing SSWD, educating people about this disease, and guiding future research. This article, therefore, explored public emotions and cognitions regarding SSWD and how these might be related to knowledge and perceptions of risk associated with this disease.

Conceptual Foundation

Emotions

Emotions involve reactions that individuals express, especially when handling personal matters or events, with these emotions encompassing physiological (e.g., increased heart rate), behavioral (e.g., running away), physical or expressive (e.g., smiling), and experiential elements (e.g., experiencing joy; Bradley & Lang, 2000; Izard, 2007). Emotions are a part of daily human experiences that allow people to react to events or objects (Dolan, 2002). Human interactions with wildlife and other natural resources have historically invoked emotions where people developed responses to deal with species and settings that promoted safety and well-being (e.g., fear of attack; Jacobs, 2009, 2012). Although many interactions with wildlife and other natural resources are different today and lead to a number of additional types of emotional responses (e.g., joy from viewing wildlife and nature), the inherited emotional complexities are still part of humans (Jacobs, 2012). Given that many people desire experiences with wildlife (e.g., sea stars) and marine environments (e.g., tide pooling, viewing marine species), studying emotional responses provides insight into human experiences with species and their habitats (Jacobs, 2012).

Emotions are often researched by categorizing them into two perspectives. First, the discrete approach specifies that each emotion, such as fear, sadness, and anger, is qualitatively different from other emotions (Jacobs et al., 2014). This approach might adhere to the typical way that individuals identify their emotions, such as saying they are either joyful or sad. Second, the dimensional approach focuses on a smaller number of broader dimensions that encompass several emotions (Jacobs et al., 2014). Emotional valence is one important dimension of emotions, which describes the extent that emotions range from negative to positive affectivity with a midpoint that is neutral (Bradley & Lang, 2000; Briesemeister et al., 2012). Arousal is another dimension that refers to activation or deactivation (i.e., passivity) of emotions (Jacobs et al., 2014). Both valence and arousal can be used for classifying emotional dispositions (states vs. traits). Emotional traits involve the general overall tendency to respond emotionally to objects, situations, or events over time (i.e., stability), whereas emotional states are more specific feelings at one moment in time (Jacobs et al., 2014; Sponarski et al., 2015; Straka et al., 2019).

Studies have been conducted on emotions in response to species such as wolves (e.g., Jacobs et al., 2014; Johansson et al., 2012; Straka et al., 2019) and coyotes (e.g., Sponarski et al., 2015), and in response to locations such as coral reefs and coastal areas (e.g., Dean et al., 2018). In the context of SSWD, Lu (2015) researched emotional appeals associated with this disease and found that sadness was an effective driver for supporting policies and seeking information related to SSWD, whereas emotional appeals for hope had limited effectiveness.

Attitudes and Norms

Human responses to natural resource issues (e.g., wildlife, marine issues) not only consist of emotional expressions, but they also involve cognitive dispositions and processes of reasoning, evaluation, and decision-making (Manfredo, 2008; Vaske & Manfredo, 2012). Two of the most commonly studied cognitions are attitudes and norms. The cognitive component of attitudes is typically defined as an assessment of circumstances, objects, conditions, or activities with some degree of favor or disfavor (Eagly & Chaiken, 1993; Fishbein & Ajzen, 2010). One conceptualization of norms defines them as standards that individuals use for evaluating whether activities, environments, or conditions should or should not be allowed to occur (Vaske & Whittaker, 2004). Personal norms can be aggregated to assess broader societal norms about an issue (Vaske & Whittaker, 2004). The target of an attitude or norm can be general (e.g., attitudes or norms concerning the environment or the entire ocean) or more specific (e.g., attitudes or norms concerning a specific issue such as SSWD; Vaske & Manfredo, 2012).

Little research has examined attitudes and norms associated with SSWD in particular. However, studies have examined attitudes and norms associated with other marine issues such as the deep-sea environment, environmental contamination of marine areas, marine ecosystem restoration, and the designation and management of marine protected areas (e.g., Ankamah-Yeboah et al., 2020; Jacobs et al., 2015; Johnston et al., 2020; Needham et al., 2011; O'Connor et al., 2020; Perry et al., 2017). A large number of studies have also examined attitudes and norms associated with human interactions with wildlife (see Manfredo et al., 2004; Milfont & Duckitt, 2010; Vaske & Manfredo, 2012; Vaske & Whittaker, 2004 for reviews).

Knowledge

Attitudes, norms, and emotions may be influenced by knowledge. There are two common types of knowledge. First, self-assessed knowledge or awareness is subjective where there is no correct answer and individuals simply believe they are informed, aware, or knowledgeable about a topic (e.g., "how knowledgeable do you feel;" Perry et al., 2014; Wann & Branscombe, 1995). Second, factual knowledge is when someone either knows or does not know something that has a factually correct or incorrect answer (Perry et al., 2014; Wann & Branscombe, 1995). Factual knowledge is often measured by asking true/false or multiple-choice questions where there is one correct answer (e.g., Perry et al., 2014; Vaske et al., 2006).

Although public knowledge related to SSWD has received little empirical attention, knowledge about marine environments in general (e.g., "ocean literacy;" Guest et al., 2015; Steel et al., 2005) and also specific marine issues such as ocean acidification (OA; Cooke & Kim, 2015; Spence et al., 2018) and marine protected areas (Perry et al., 2014) has been examined. Research has also examined knowledge related to wildlife issues (e.g., Bonneau et al., 2009; Lessard et al., 2017; Vaske et al., 2006). In most studies of the general public, factual knowledge about marine and wildlife issues tends to be quite low. Perry et al. (2014), for example, found that when tested on facts regarding marine reserves along the Oregon coast, 65% of the public answered half or fewer of the questions correctly. Similarly, Vaske et al. (2006) found that 32–44% of their respondents failed to correctly answer factual knowledge questions about a wildlife disease.

Research has shown that factual knowledge can be associated with emotions, attitudes, and norms. Spence et al. (2018), for example, found that respondents who scored higher on a knowledge test about OA were more worried about this issue. Jim and Xu (2002) reported that the public had low knowledge about a newly established reserve, but positive attitudes toward this reserve. Wachholtz et al. (2014) found that students had negative attitudes toward climate change, but were also largely unaware of the causes and outcomes of climate change. In a wildlife context, examples include: (a) Bonneau et al. (2009) who found that low knowledge about ecology, management, and consumptive uses of wildlife was related to less support regarding the management of wildlife habitat and populations; and (b) Lessard et al. (2017) who reported low respondent knowledge about an endangered bird species, but favorable attitudes toward conservation of this species.

Perceived Risk

Perceptions of risk may also be associated with attitudes, norms, and emotions. Perceived risk involves how much individuals believe that a hazard (e.g., SSWD) could impact or threaten themselves, other people, or something else (e.g., marine areas, the environment; Sjöberg, 2000). These risk targets, such as groups who may be impacted by a hazard, have the ability to sway an individual's risk perception (Sjöberg, 2000). Compared to objective risk assessments (i.e., actual probabilities and consequences of hazards), perceived risks are subjective evaluations of hazards (Slovic, 2010). Risk denial occurs when an individual attributes greater risk to another risk target (e.g., other people) than to themselves, and this comes from the individual's belief that they could stop or are immune to a personal threat (Sjöberg, 2000). Conversely, risk sensitivity occurs when an individual possesses a predisposition to rate most risks in life as large and believes that most risks, no matter what they are, pose serious threats (Needham et al., 2017; Sjöberg, 2004).

Little research has examined risk perceptions in the context of SSWD, but this concept has been studied in a variety of other contexts related to marine and wildlife issues, including risk perceptions associated with climate change (Lacroix & Gifford, 2017), marine recreation (Morgan & Stevens, 2008), wildlife species (e.g., Riley & Decker, 2008; Sponarski et al., 2016), and wildlife diseases and related hazards (e.g., Needham & Vaske, 2008; Needham et al., 2017). Studies have found that these perceived risks can be related to emotions, attitudes, and norms. Johansson et al. (2012), for example, found that emotional fears toward bears and wolves were associated with social psychological and cognitive antecedents related to risks (e.g., considering the species to be dangerous and unpredictable). A number of studies have also found that low perceived risks are often associated with normative acceptance and positive attitudes (e.g., Siegrist, 2000; Sjöberg, 2004; Vaske et al., 2004). Sakurai et al. (2013), for example, found high perceived risks toward bears negatively correlated with positive attitudes toward the species.

Research Questions

This body of research has also shown in various contexts that emotions, attitudes, norms, knowledge, and perceived risks can change as natural resource conditions improve or deteriorate (e.g., Ceurvorst & Needham, 2012; Needham et al., 2006; Vaske & Manfredo, 2012). For example, if SSWD is not present, the public may not be concerned, but responses may become more negative as conditions worsen. This article, therefore, explored the following research questions:

1. To what extent is the public factually knowledgeable about SSWD?
2. How much risk does the public perceive is associated with SSWD?
3. What are public emotions, attitudes, norms, and awareness in response to SSWD?
4. To what extent do these emotions, attitudes, norms, and awareness change as conditions related to SSWD deteriorate?
5. To what extent do these changes in emotions, attitudes, norms, and awareness in response to deteriorating SSWD conditions differ among subgroups of the public based on their factual knowledge and perceptions of risk?

Methods

Data Collection

Data were obtained from two strata of Oregon residents. The first stratum included residents of zip codes along the Oregon coast and west of the Coast Mountain Range. These individuals live closest to the ocean (i.e., less than a 30 minute drive to the Oregon coast), so are likely to be most aware of marine issues such as SSWD. However, data from this population are not necessarily reflective of dynamics in other regions of this state or of broader societal relationships with the ocean (Johnston et al., 2020). The second stratum, therefore, included residents of zip codes in the most heavily populated region of Oregon (i.e., cities of Portland to Ashland between the Coast and Cascade Mountain Ranges, which is a 1–2 hour drive to the Oregon coast). This non-coastal population constitutes the majority of Oregon's voting population and is more socially, culturally, politically, and economically diverse compared to some other areas of this state (Johnston et al., 2020). Although this population is arguably not as aware of or directly invested in marine issues as coastal residents, this population provides insights into views held by residents of the most populous region of this state.

An online questionnaire was administered from January 5 to 19, 2021 to members of the Qualtrics Research Panel who were 18 years of age or older and resided in a zip code in these areas. Internet panels such as these consist of self-selected individuals who voluntarily join and are paid to complete online questionnaires on various topics multiple times a year. These panels can be cost effective and generate data rapidly, but there are some challenges such as accurately estimating sample representativeness and sampling error, difficulty ensuring a perfectly random sample (i.e., they usually involve nonprobability samples), and the low tolerance of some panel members to long questionnaires (Brandon et al., 2014; Vaske, 2019). Some respondents also have a tendency to skip questions or provide identical answers to all items in a set of scale questions to complete questionnaires quickly (i.e., straight-lining; Brandon et al., 2014; Vaske, 2019).

To address these challenges, the questionnaire required responses to all questions and also contained four attention filter questions that necessitated particular responses (e.g., "if you are reading this, select 'slightly support'"). A soft launch was sent to 42 individuals to check response accuracy, comprehension, and completion time. A speeding check, measured as one-half the median soft launch time (20 minutes), was implemented to ensure that respondents were not speeding through the questionnaire and completing it in less than 10 minutes. Respondents who repeatedly straight-lined, answered any of the attention filters incorrectly, or failed the speeding check were excluded from the final dataset. The final total sample size was n = 507 (coast = 82, most heavily populated region = 425). The reasons for this difference in sample sizes between the coast and most heavily populated region are: (a) sampling was conducted relatively proportionate to population size (e.g., the coast has a much smaller total population), and (b) there are far fewer members of the Qualtrics Research Panel living along Oregon's coast than in its most heavily populated region. Partial responses were not recorded, so a response rate cannot be calculated and it is rare to accurately calculate response rates for internet panels (Brandon et al., 2014). A non-response bias check was not performed because other contact information of panel members (e.g., telephone numbers, addresses) is not available for most internet panels. The data were, however, weighted by demographic characteristics (e.g., male/female, education) from census information to improve sample representativeness to the population (Vaske, 2019).

Independent Variables

The two independent variables were factual knowledge about SSWD and perceived risk associated with this disease. To measure factual knowledge, participants were asked whether they believed that five statements about SSWD were either true or false (or unsure). These statements are listed in Table 1 and this approach for measuring factual knowledge is identical to studies on other natural resource issues (e.g., Perry et al., 2014; Vaske et al., 2006). To measure perceived risk associated with SSWD, participants were asked how much they thought this disease posed risks to the six different targets that are listed in Table 1. These risks were measured on eight-point scales of 1 "no risk" to 8 "high risk." This approach is consistent with other studies measuring risk perceptions (e.g., Needham et al., 2017; Petit et al., 2021).

Table 1. Respondent factual knowledge and perceptions of risk associated with SSWD.

	Frequencies
Factual knowledge [a]	
Sea star wasting disease can cause the health of sea stars to decline quickly (True)	71
Sea star wasting disease has caused millions of sea stars to die along the west coast of North America (True)	49
Sea star wasting disease only affects one type (species) of sea star (False)	40
Sea star wasting disease has never been found in Oregon's marine or coastal areas (False)	35
The cause of sea star wasting disease is linked to a virus (True)	17
Total mean (*M*) 0–5 correct (standard deviation [*SD*])	2.11 (1.49)
Perceived risk – How much do you think SSWD poses a risk to: [b]	
Tide pools along the shore/coast	5.80 (1.42)
Marine areas (the ocean) in general	5.60 (1.37)
Other species living in marine areas	5.16 (1.61)
The tourism industry	4.39 (1.85)
Other humans or society in general (e.g., health, jobs)	3.59 (1.73)
Yourself (e.g., health, jobs)	3.25 (1.81)

[a]Cell entries are percent (%) who answered correctly unless specified as means (*M*) and standard deviations (*SD*) in parentheses.
[b]Cell entries are means (*M*) with standard deviations (*SD*) in parentheses on 8-point scale of 1 "no risk" to 8 "high risk."

Dependent Variables

Five different scenarios were embedded in the questionnaire to measure emotions, attitudes, norms, and awareness in response to deteriorating conditions of sea stars impacted by SSWD. Images in the questionnaire depicted these deteriorating conditions (Figure 1) with the first image showing seven relatively intact and healthy sea stars, and each subsequent image showing progressively worse evidence and consequences of SSWD until the fifth image that showed only one sea star with only two attached limbs remaining. Scenarios and image-based approaches such as these have been used in studies examining the human dimensions of various marine and wildlife issues (e.g., Ceurvorst & Needham, 2012; Manning & Freimund, 2004; Needham et al., 2006).

Below each image were questions measuring four dependent variables in response to the conditions depicted in each image: (a) emotions, (b) attitudes, (c) norms, and (d) awareness. Five different emotions were measured after asking respondents how each image made them feel (fearful, angry, surprised, disgusted, sad) on eight-point scales of 1 "not at all" to 8 "extremely." This approach for measuring emotions is consistent with previous studies (e.g., Ekman & Friesen, 1971; Izard, 2007; Jacobs et al., 2014). Attitudes were measured with two

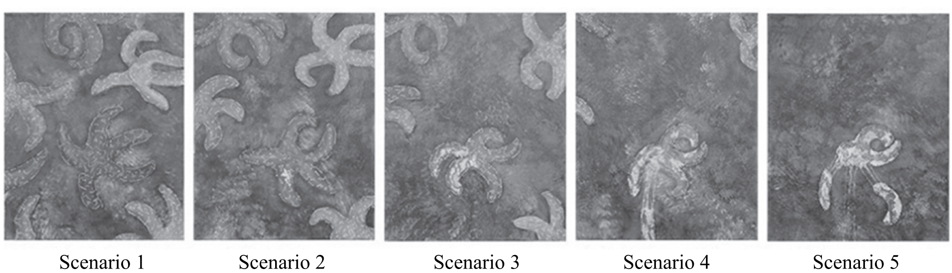


Figure 1. Scenarios embedded in the questionnaire for measuring responses to deteriorating SSWD conditions. These were shown in color to respondents (images courtesy of Marissa Solini and used with permission; for these images in color, see: https://cargocollective.com/marissasolini/Sea-Star-Wasting-Syndrome-Pisaster-ochraceus).

different cognitive responses (good, like) to each image on the same eight-point scale. This method is identical to other studies measuring attitudes (e.g., Perry et al., 2017; Sponarski et al., 2015). Norms in response to each image were measured on two nine-point scales of 1 "very unacceptable" to 9 "very acceptable" and 1 "should definitely not allow" to 9 "should definitely allow." These scales are commonly used for measuring norms (e.g., Ceurvorst & Needham, 2012; Needham et al., 2011). Awareness was measured by asking respondents "do you think the conditions in this image show evidence of SSWD" with responses of "no," "yes," and "unsure." These questionnaire items were repeated with identical wording below each of the five images.

Data Analysis

Responses to the five questions measuring factual knowledge were recoded as 0 "did not answer correctly" (included "unsure") and 1 "answered correctly," summed to create a total knowledge score (0–5 correctly answered), and dichotomized into lower and higher knowledge groups based on the median split. K-Means cluster analysis of the six risk targets was used for grouping respondents into lower and higher risk groups. Combining these factual knowledge and perceived risk groups into a matrix resulted in four groups (lower risk, lower knowledge; lower risk, higher knowledge; higher risk, lower knowledge; higher risk, higher knowledge).

The multiple item indices measuring emotions, attitudes, and norms were tested for measurement reliability using Cronbach's alpha (Vaske, 2019). Impact acceptability curves (see Vaske & Whittaker, 2004 for a review) were then used for displaying and analyzing the extent that emotions, attitudes, norms, and awareness changed as SSWD conditions deteriorated across the five scenarios. These curves show how the mean emotions and cognitions change across the scenarios. Another measure on these curves is crystallization, which involves the consensus or agreement among respondents. One common approach for measuring crystallization is to average the standard deviations for points comprising the curve (Ceurvorst & Needham, 2012).

Bivariate chi-square (χ^2) tests, independent samples *t*-tests, and one-way analysis of variance (ANOVA, *F*) tests with their associated effect sizes (e.g., Cramer's *V*, point-biserial correlation [r_{pb}], eta [η]) examined the extent that emotions, attitudes, norms, and awareness differed among groups based on their factual knowledge and perceptions of risk. A statistical significance level of $p \leq .01$ was adopted based on the Bonferroni correction procedure to reduce the possibility of false discoveries and multiple test bias given the five scenarios (i.e., multiple comparison problem, family-wise error; Vaske, 2019). Responses to all questions examined in this article were also tested for any differences between the two strata (coast, most heavily populated region) and only 13 of the 71 (18%) tests were statistically significant. Effect sizes ranged from .01 to .21 and averaged only .07. Using guidelines from Cohen (1988) and Vaske (2019), these effect sizes suggested that the strength of any differences between the strata was "small" or "minimal." Given these small effect sizes and the fact that 82% of the tests showed no statistical differences, the responses from these two strata were aggregated into a single public sample.

Results

Respondents correctly answered an average of only 42% of the questions measuring factual knowledge about SSWD (2.11/5 correct; Table 1). Respondents were most likely to know that SSWD can cause the health of sea stars to decline quickly (71%) and least likely to know that the cause of SSWD is linked to a virus (17%). In total, 20% of respondents answered none of the questions correctly and only 4% answered every question correctly. The largest proportion of respondents (25%) answered three of the five questions correctly. The median split was 2, so 0–2 correct responses were categorized as lower knowledge (55%) and 3–5 correct responses were labeled as higher knowledge (45%).

Respondents felt that SSWD represented a slight risk to themselves, other humans, and the tourism industry, and a moderate risk to tide pools, marine areas, and other marine species (Table 1). Respondents thought that SSWD posed the greatest risk to tide pools. A series of two- to six-group cluster analyses of these six risk targets showed that the two-group solution provided the best fit where respondents who rated all risks the lowest (54%) were labeled lower risk and those who rated all risks the highest (46%) were higher risk. Combining the two knowledge groups (lower and higher knowledge) with these two risk groups (lower and higher risk) created four possible combinations: lower risk, lower knowledge (32%); lower risk, higher knowledge (22%); higher risk, lower knowledge (23%); and higher risk, higher knowledge (23%).

There were no statistically significant relationships between knowledge about SSWD and age, sex (e.g., male, female), and education. There were also no relationships between risks of SSWD and both age and sex. There was a statistically significant relationship between education and risks of SSWD with more educated respondents perceiving slightly greater risks, $\chi^2 = 23.24$, $p < .001$, $V = .21$. Personally seeing sea stars before answering the questionnaire was not significantly related to risks associated with SSWD, but it was for knowledge with those who had seen sea stars having slightly greater knowledge about SSWD, $\chi^2 = 21.90$, $p < .001$, $V = .20$.

Cronbach alpha reliability analyses were performed on the three dependent concepts measured with multiple variables on scales (emotions, attitudes, norms) for each of the five SSWD scenarios (Table 2). Alphas ranged across scenarios from .87-.92 for emotions, .87-.96 for attitudes, and .82-.90 for norms. These coefficients exceeded the standard of > .65 suggested by Vaske (2019), removing any variables did not improve reliability, and the item-total correlations ranged from .48 to .92. These results showed consistency among the variables measuring each concept and justified computing composite indices for each concept for each scenario.

As impacts from SSWD worsened from scenarios 1 to 5, the emotions, attitudes, and norms became more negative (Figure 2). As impacts from SSWD worsened, awareness that the scenarios showed evidence of SSWD increased. Compared to respondents with lower knowledge about SSWD, those with higher knowledge had more negative emotions, attitudes, and norms. Respondents with higher knowledge were also more likely to be aware that the scenarios showed evidence of SSWD. The differences in emotions between these two knowledge groups were statistically significant for scenarios 2 to 4 and the effect sizes showed that these differences were between “small” and “medium” (Cohen, 1988) or “minimal” and “typical” (Vaske, 2019). For attitudes and norms, the differences between these two groups were not significant for any scenario. All scenarios except the second

Table 2. Variables and scale reliabilities for emotions, attitudes, and norms in response to the SSWD scenarios [a]

	Item-total correlation	Alpha if item deleted	Cronbach alpha
Emotions [b]			.87 – .92
Fearful	.73 – .81	.83 – .89	
Angry	.82 – .87	.80 – .88	
Surprised	.48 – .60	.87 – .92	
Disgusted	.75 – .84	.82 – .88	
Sad	.67 – .80	.85 – .89	
Attitudes [c]			.87 – .96
Good	.76 – .92	–	
Like	.76 – .92	–	
Norms			.82 – .90
Acceptance scale [d]	.70 – .81	–	
Should scale [e]	.70 – .81	–	

[a]Cell entries represent ranges from lowest to highest across the five SSWD scenarios.
[b]Measured on 8-point scales of 1 "not at all" to 8 "extremely" and these were then reverse coded for analysis so the highest number represented the most positive emotion and the lowest number represented the most negative.
[c]Measured on 8-point scales of 1 "not at all" to 8 "extremely."
[d]Measured on 9-point scale of 1 "very unacceptable" to 9 "very acceptable."
[e]Measured on 9-point scale of 1 "should definitely not allow" to 9 "should definitely allow."

scenario showed significant differences in awareness between these two groups with "small" to "medium" (Cohen, 1988) or "minimal" to "typical" (Vaske, 2019) effect sizes. The Levene's tests for homogeneity did not show any significant differences between groups in their crystallization or consensus for emotions, attitudes, or norms.

Compared to respondents who perceived lower risks from SSWD, those who perceived higher risks generally had more negative emotions, attitudes, and norms (Figure 3). Respondents perceiving higher risks were also more likely to be aware that the scenarios showed evidence of SSWD. The differences in emotions between these two risk groups were statistically significant for all of the scenarios and the effect sizes showed that these differences ranged from "small" (Cohen, 1988) or "minimal" (Vaske, 2019) for scenario 1 to relatively "large" (Cohen, 1988) or "substantial" (Vaske, 2019) for scenario 4. For attitudes and norms, the differences between the groups were not significant for any scenario. Only scenario 1 showed significant differences in awareness between these two groups with a relatively "small" (Cohen, 1988) or "minimal" (Vaske, 2019) effect size. The Levene's tests did not show any significant differences between the two risk groups in their crystallization or consensus for emotions, attitudes, or norms.

For the four combined risk and knowledge groups (lower knowledge, lower risk; lower risk, higher knowledge; higher risk, lower knowledge; higher knowledge, higher risk), the lower risk and lower knowledge group generally had the most positive emotions, attitudes, and norms across the scenarios (Figure 4). This group was also among the least aware that the scenarios showed evidence of SSWD. Conversely, the higher risk and higher knowledge group was most aware that the scenarios showed evidence of SSWD and this group also had the most negative emotions, attitudes, and norms across the scenarios. Responses from the other groups (lower risk, higher knowledge; higher risk, lower knowledge) generally fell in between these two groups. The differences in emotions among these four groups were statistically significant for all scenarios and the effect sizes showed that these differences ranged from "small" (Cohen, 1988) or "minimal" (Vaske, 2019) for scenario 1 to relatively "large" (Cohen, 1988) or

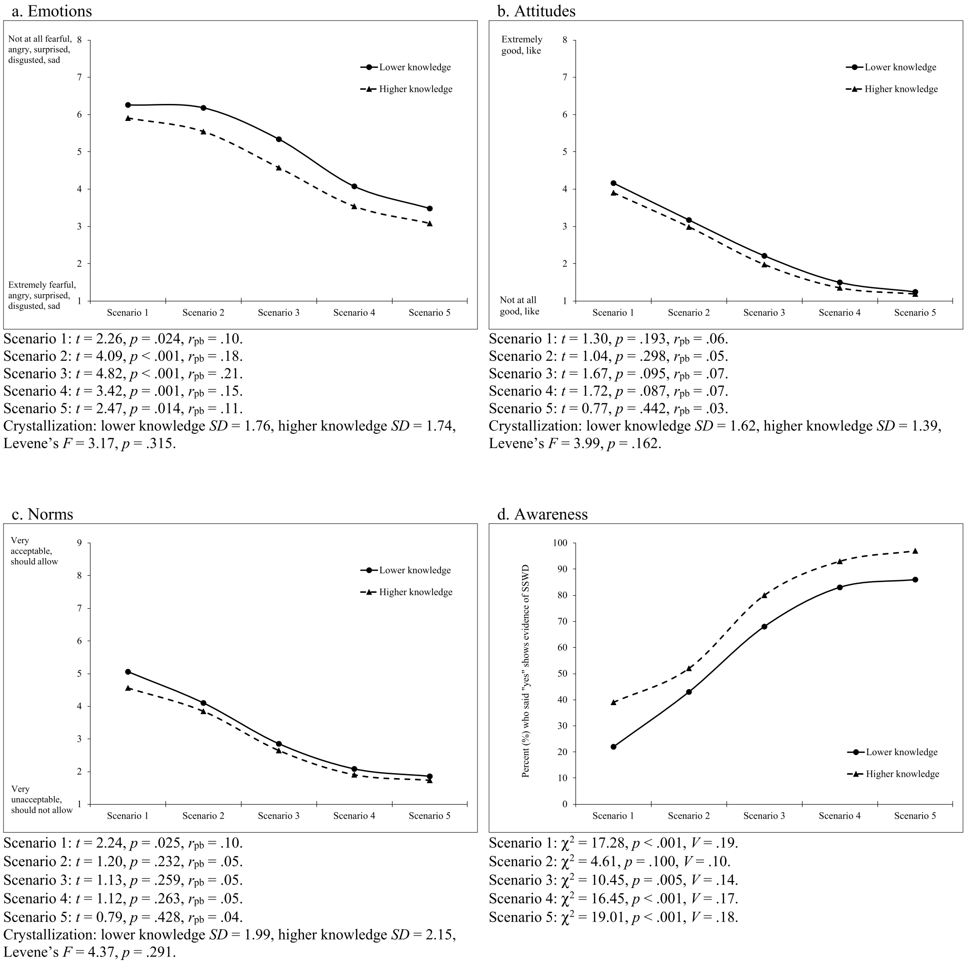


Figure 2. Emotions, attitudes, norms, and awareness in response to the SSWD scenarios for lower and higher knowledge groups.

"substantial" (Vaske, 2019) for scenarios 3 and 4. For attitudes and norms, the differences among the four groups were not significant for any scenario. For awareness, the differences among the four groups were significant for all five scenarios, but the effect sizes were relatively "small" (Cohen, 1988) or "minimal" (Vaske, 2019). The Levene's tests did not show any significant differences among these four groups in their crystallization or consensus for emotions, attitudes, or norms.

Discussion

Implications for Managers and Other Practitioners

These results have implications for both practitioners and researchers. From a practitioner perspective (e.g., managing government agencies, non-governmental organizations), this sample of Oregon residents had relatively low factual knowledge about SSWD, suggesting

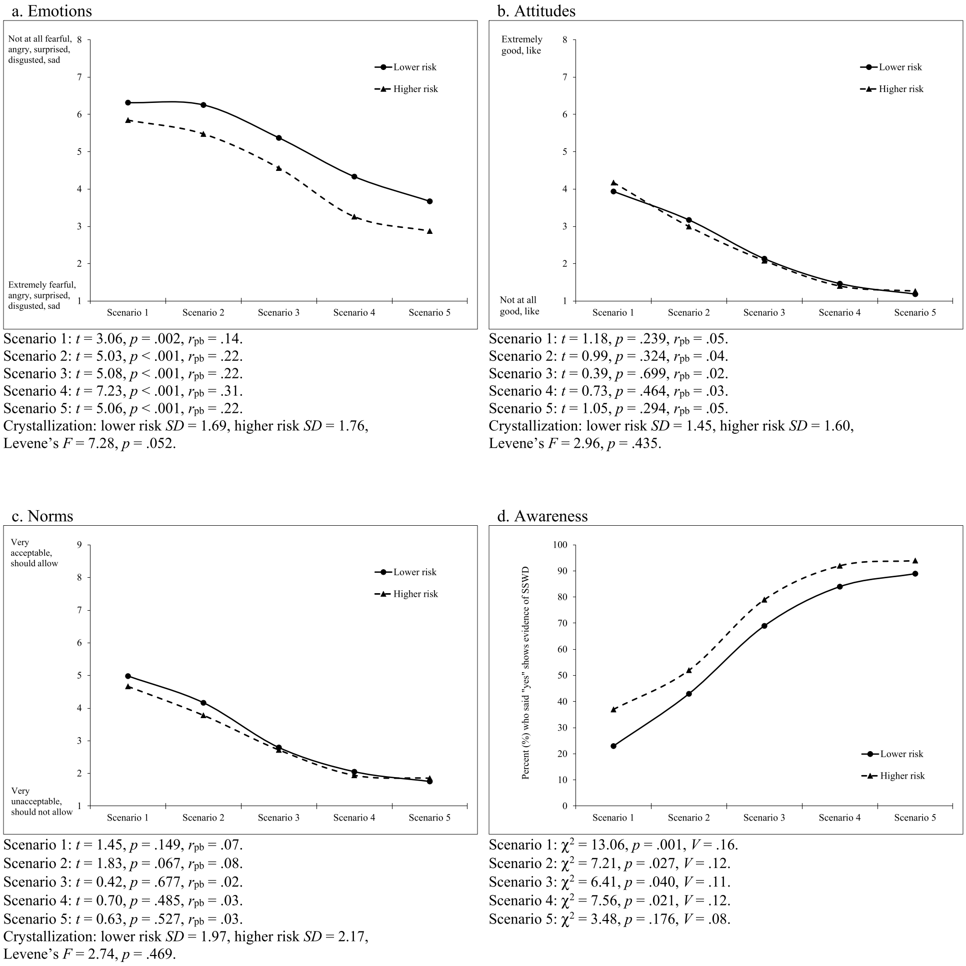
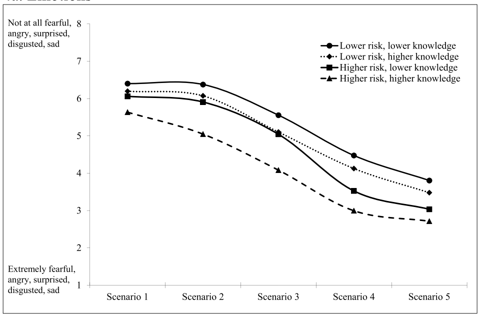


Figure 3. Emotions, attitudes, norms, and awareness in response to the SSWD scenarios for lower and higher risk perception groups.

a need to improve outreach and information efforts about this topic. Practitioners could focus on providing more information and interpretation about SSWD through resources at science centers, aquariums, websites, social media sites, and other educational outlets. Targeting specific interest groups (e.g., recreationists who visit tide pools) with information about SSWD could also expand knowledge and provide useful information about the potential impacts of SSWD for those groups.

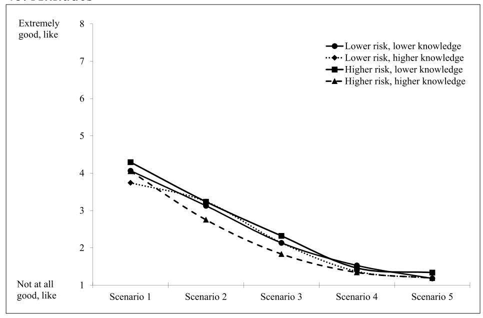
This sample was least knowledgeable of the cause of SSWD, where this disease has been found, and what species of sea stars this disease impacts, so information about these issues could be prioritized. That said, public knowledge about marine environments in general tends to also be quite low (e.g., "ocean literacy;" Guest et al., 2015; Steel et al., 2005) and although overall ocean literacy was not measured here, it is possible that this sample's relatively low knowledge about SSWD reflects a similarly low level of knowledge about marine environments in general. Therefore, providing information to the public about issues related to SSWD may also help to heighten knowledge about marine environments in

4a. Emotions



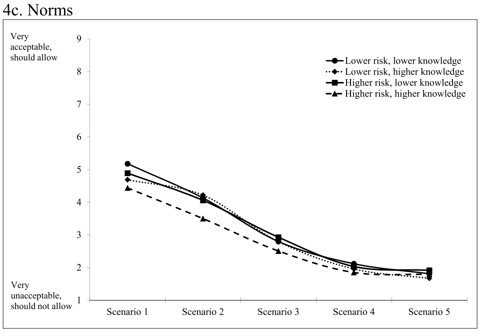
Scenario 1: $F = 4.61$, $p = .003$, $\eta = .16$.
Scenario 2: $F = 14.75$, $p < .001$, $\eta = .29$.
Scenario 3: $F = 16.61$, $p < .001$, $\eta = .30$.
Scenario 4: $F = 20.14$, $p < .001$, $\eta = .33$.
Scenario 5: $F = 9.76$, $p < .001$, $\eta = .24$.
Crystallization: lower risk, lower knowledge $SD = 1.68$; lower risk, higher knowledge $SD = 1.69$; higher risk, lower knowledge $SD = 1.80$; higher risk, higher knowledge $SD = 1.65$; Levene's $F = 3.23$, $p = .134$.

4b. Attitudes



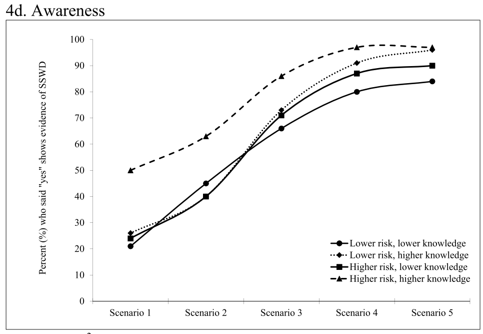
Scenario 1: $F = 1.16$, $p = .326$, $\eta = .08$.
Scenario 2: $F = 1.52$, $p = .207$, $\eta = .10$.
Scenario 3: $F = 1.89$, $p = .130$, $\eta = .11$.
Scenario 4: $F = 1.03$, $p = .378$, $\eta = .08$.
Scenario 5: $F = 1.00$, $p = .393$, $\eta = .08$.
Crystallization: lower risk, lower knowledge $SD = 1.50$; lower risk, higher knowledge $SD = 1.37$; higher risk, lower knowledge $SD = 1.76$; higher risk, higher knowledge $SD = 1.40$; Levene's $F = 3.37$, $p = .123$.

4c. Norms



Scenario 1: $F = 2.25$, $p = .082$, $\eta = .12$.
Scenario 2: $F = 2.25$, $p = .081$, $\eta = .12$.
Scenario 3: $F = 0.88$, $p = .453$, $\eta = .07$.
Scenario 4: $F = 0.54$, $p = .659$, $\eta = .06$.
Scenario 5: $F = 0.38$, $p = .764$, $\eta = .05$.
Crystallization: lower risk, lower knowledge $SD = 1.92$; lower risk, higher knowledge $SD = 2.04$; higher risk, lower knowledge $SD = 2.09$; higher risk, higher knowledge $SD = 2.23$; Levene's $F = 2.08$, $p = .449$.

4d. Awareness



Scenario 1: $\chi^2 = 34.60$, $p < .001$, $V = .19$.
Scenario 2: $\chi^2 = 21.87$, $p = .001$, $V = .15$.
Scenario 3: $\chi^2 = 17.53$, $p = .008$, $V = .13$.
Scenario 4: $\chi^2 = 24.72$, $p < .001$, $V = .15$.
Scenario 5: $\chi^2 = 23.42$, $p < .001$, $V = .14$.

Figure 4. Emotions, attitudes, norms, and awareness in response to the SSWD scenarios for the combined risk and knowledge groups.

general. This is especially important given the many cultural ecosystem services provided by marine environments and species (e.g., recreation, aesthetic, artistic, heritage, bequest, educational; Gould & Lincoln, 2017).

In the context of self-assessed knowledge or awareness, as impacts of SSWD worsened across each of the scenarios, awareness that the scenario showed evidence of SSWD increased. This is important because it shows that respondents knew when SSWD became more problematic, so practitioners could perhaps reduce public information about signs of effects from SSWD and instead provide more information about specific aspects of SSWD such as impacts to intertidal ecosystems, what causes SSWD, and potential techniques for mitigating this disease.

Respondents also felt that SSWD poses a much greater risk to marine environments and species than to themselves and other people. This suggests these residents understand that SSWD poses risks to the ocean, but they are not making a strong connection that risks to the ocean also pose risks to humans. SSWD impacts sea stars and various aspects of intertidal ecosystems (e.g., creatures living in tide pools) that humans enjoy for viewing and research. SSWD may also impact other ecosystem components, as it may alter the food supply (e.g., fish, crabs, sea otters that feed on sea stars) for larger megafauna such as sharks and seals (National Aquarium, 2020). These other species provide cultural ecosystem services (e.g., whale watching) and also food for humans (Grose et al., 2020). Failing to connect risks of SSWD to themselves and other humans suggests that there is a need for more public information about other potential effects of SSWD including the fact that climate change is a potential contributor to SSWD that affects people around the world (Harvell et al., 2019). Practitioners could, therefore, consider emphasizing how SSWD has the potential to impact many ecosystems and species, not just isolated examples.

Combining the risks and factual knowledge scores showed that the lower risk, lower knowledge (32%) and higher risk, higher knowledge (23%) groups were two of the largest groups in the sample, suggesting that many respondents were polarized in their knowledge and perceptions of risk associated with SSWD. Large proportions of respondents either: (a) know little and are less concerned about SSWD, or (b) know about SSWD and are concerned, leaving a gap of fewer respondents in the middle. Practitioners could use these findings to target groups with different information about SSWD. For example, for those with low knowledge and low risk based on their questionnaire responses, basic information that defines SSWD and highlights its risks would help, with the option to learn more about SSWD for those who are interested.

Respondents' emotions were generally more positive than their cognitions (e.g., norms, attitudes) toward SSWD. Even for the first scenario that showed no obvious evidence of SSWD, their attitudes were only slightly to moderately favorable and their norms stated that conditions were only moderately acceptable or should be allowed to occur. Although speculative, these results may have occurred because sea stars may not spark the strong cognitive responses that are often expressed for more charismatic megafauna such as dolphins, whales, and sharks (Albert et al., 2018). Cognitions involve more thought than emotional responses, but both are important for information processing and persuasion models such as the Elaboration Likelihood Model (ELM) and Heuristic-Systematic Model (HSM), which involve: (a) central or systematic routes where people are provided with detailed and cognition provoking messages, and (b) peripheral or heuristic routes that provide simple and more emotional messages, cues, and images (Eagly & Chaiken, 1993). In their science communication efforts, practitioners could consider integrating both types of messaging to target both emotional and cognitive responses associated with SSWD. In addition, the trend of more negative emotions and cognitions as conditions deteriorated across the scenarios suggests that respondents were concerned about the issue and do not want SSWD to impact sea stars. As conditions deteriorated, respondents were also more likely to know that these conditions showed evidence of SSWD. These findings suggest that many respondents already understand that SSWD has negative outcomes, so practitioners may be able to provide more specific and targeted forms of information when communicating about this disease.

There were no substantive differences between the coastal and inland (i.e., more heavily populated area) samples in the context of responses to SSWD. Arguably, coastal residents should be more aware of and directly invested in marine issues due to their proximity to the ocean, but this was not the case here. Given that SSWD is thought to be related to climate change (i.e., as oceans warm, the impacts of SSWD worsen; Harvell et al., 2019) that is broadly acknowledged and transcends geographical locations, perhaps living in close proximity to the ocean is less important in the context of emotions and cognitions associated with SSWD. The inland sample also lives in relatively close proximity to the Oregon coast (e.g., just a 1–2 hour drive), so many of these residents have easier access to marine environments compared to those living in the inland and landlocked states. From a practitioner perspective, this suggests that targeting different messages about SSWD to coastal versus inland Oregon residents may not be necessary; both groups could be targeted with similar informational and interpretive messaging. As part of this information and messaging about SSWD, practitioners could also consider engaging in more interactive, two-way engagements with the public, such as through community meetings and focus groups.

Implications for Researchers

From a research perspective, factual knowledge about SSWD was quite low among this public sample, which is consistent with research on other marine and natural resource topics (e.g., Perry et al., 2014; Vaske et al., 2006). Respondents with higher knowledge about SSWD had more negative emotions, attitudes, and norms toward this issue (although attitudes and norms were not statistically significant, the patterns were generally consistent), which is also consistent with past research on marine and natural resource topics (e.g., Bonneau et al., 2009; Jim & Xu, 2002; Lessard et al., 2017; Spence et al., 2018; Wachholtz et al., 2014). Spence et al. (2018), for example, found that respondents with higher knowledge about OA were more worried about this issue. In a wildlife context, Bonneau et al. (2009) found that low knowledge about ecology, management, and consumptive uses of wildlife was related to lower support regarding the management of wildlife habitat and populations. Respondents with higher knowledge about SSWD were also more aware that conditions depicted in the scenarios showed evidence of this disease, which is similar to research that has found positive relationships between factual and self-assessed knowledge (Belden et al., 1999; Perry et al., 2014; Steel et al., 2005).

In addition to knowledge about SSWD, Table 1 also showed that respondents felt this issue posed only slight risks to themselves, but greater risks to other targets (e.g., marine areas, tide pools, other marine species), which could be evidence of some risk denial (i.e., attribute greater risk to another target than to themselves; Sjöberg, 2000). A large proportion of respondents also considered SSWD to be a moderate or higher risk overall, which is consistent with research on other marine topics related to this issue such as OA (e.g., Cooke & Kim, 2018; Spence et al., 2018). In addition, those who perceived higher risks had more negative emotions, attitudes, and norms (although attitudes and norms were not statistically significant, the patterns were generally consistent), which is consistent with previous research on other marine and wildlife topics (e.g., Capstick et al., 2016; Johansson et al., 2012; Sakurai et al., 2013; Spence et al., 2018; Vaske et al., 2004). Both Capstick et al. (2016) and Spence et al. (2018), for example, found that negative emotions and affective responses associated with OA and climate change were related to increased risks and concerns about this issue. In a wildlife context, Sakurai et al. (2013) found high perceived risks toward bears negatively correlated with positive attitudes toward the species. Respondents who perceived higher risks were also more likely to be aware that the scenarios showed evidence of SSWD, which is consistent with research on relationships between risk and awareness or knowledge. Lee et al. (2015), for example, found that knowledge about causes of climate change was correlated with perceptions of risk about threats to the ocean. Connecting both risk and knowledge, the low risk, low knowledge and high risk, high knowledge groups were generally most polarized in their emotional, attitudinal, and normative responses across the scenarios (although attitudes and norms were not statistically significant, the patterns were generally consistent). In a different marine context, Capstick et al. (2016) found similar results where directly referencing climate change when discussing OA resulted in relatively polarized responses toward this issue.

Respondent emotions were highly positive for the first scenario that showed no obvious evidence of SSWD, but emotions declined quickly as conditions deteriorated. This is consistent with findings from Lu (2015), Capstick et al. (2016), and Mabardy et al. (2015) who found that SSWD or other threats to marine areas evoked a number of negative emotions such as feeling sad and angry. From a measurement perspective, the high reliability of the emotion variables measured here demonstrated consistency with the dimensional approach to measuring emotions (i.e., smaller number of broader dimensions that encompass several discrete emotions; Jacobs et al., 2014). The discrete emotion variables (e.g., fearful, surprised, sad) combined to measure the valence dimension of emotions (i.e., from negative to positive affectivity; Bradley & Lang, 2000; Briesemeister et al., 2012) and respondents' emotional valence disposition influenced how they responded to the SSWD conditions depicted in the scenarios. This is consistent with previous research (e.g., Sponarski et al., 2015; Straka et al., 2019) and suggests that through measuring discrete emotional dispositions, it is possible to simultaneously measure valence dispositions as well. This idea is similar to how affective responses (e.g., emotions) can be interrelated rather than being independent (Russell, 1980). Future research should build on this study and previous SSWD research (Lu, 2015) to measure additional emotional dispositions toward this disease. In addition, the emotions in this study generally mirror those that Natural Language Understanding and related processes (i.e., artificial intelligence, machine learning) can code for in big data and automated analyses of large datasets (Hirschberg & Manning, 2015). Examining the prevalence and patterns of emotions associated with SSWD in these data sources could be an extension that provides contextual and qualitative descriptions to emotions beyond the valence scales used here.

As conditions related to SSWD in the scenarios deteriorated, respondent emotions, norms, and attitudes became more negative. This is consistent with research in other contexts measuring responses to deteriorating natural resource conditions (Ceurvorst & Needham, 2012; Needham et al., 2006, 2011). Limited social science research has varied the levels of impact or deterioration caused by SSWD, so this study adds a new perspective of how emotions and cognitions can change as conditions associated with SSWD deteriorate. Future research should consider building on this study by incorporating additional impacts and deteriorating conditions from SSWD when measuring how people respond to this issue.

Overall, there has been little research on the social science or human dimensions aspects of SSWD (Lu, 2015), so this study contributes to the literature. There are, however, additional issues that should be considered for future studies. First, the data were obtained from a nonprobability sample, as Qualtrics Research Panel members sign up voluntarily to respond to questionnaires. Although the data were weighted by census information to be more demographically representative of the target population, non-probability samples are not necessarily representative of larger populations. Future research should conduct random probability samples and compare results to those reported here to determine any similarities or differences. Second, the public sample of residents did not deliberately target any special interest groups (e.g., researchers, agencies, council members, task forces, science panels) who likely have more knowledge and involvement associated with SSWD. Third, the scenarios used images, which depict static conditions in time. Videos or other multimedia may show more dynamic and realistic conditions related to SSWD (Manning & Freimund, 2004). The scenarios were also presented in the questionnaire in the same order (increasing in impact) and were not randomized in their order, so research should test for potential starting point bias and order effects. Fourth, consistent with some research (see Jacobs et al., 2012 for a review), this study did not measure the arousal dimension of emotions (e.g., relaxed, energetic), so research is needed to examine if SSWD triggers any arousal responses (Jacobs et al., 2014). Finally, these results are limited to this one sample of Oregon residents and the generalizability of findings to other populations and geographical areas remains a topic for further empirical investigation.

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References

Albert, C., Luque, G., & Courchamp, F. (2018). The twenty most charismatic species. *PLOS One*, *13*(7) , e0199149. https://doi.org/10.1371/journal.pone.0199149

Ankamah-Yeboah, I., Xuan, B., Hynes, S., & Armstrong, C. (2020). Public perceptions of deep-sea environment: Evidence from Scotland and Norway. *Frontiers in Marine Science*, *7*, 137. https://doi.org/10.3389/fmars.2020.00137

Belden, R., & Stewart, American Viewpoint. (1999). *Communicating about oceans: Results of a national survey*. The Ocean Project.

Bonneau, L., Darville, R., Legg, M., Haggerty, M., & Wilkins, R. (2009). Changes in volunteer knowledge and attitudes as a results of Texas master naturalist training. *Human Dimensions of Wildlife*, *14*(3), 157–172. https://doi.org/10.1080/10871200902838722

Bradley, M., & Lang, P. (2000). Measuring emotion: Behavior, feeling and physiology. In R. Lane & L. Nadel (Eds.), *Cognitive neuroscience of emotion* (pp. 242–276). Oxford University Press.

Brandon, D., Long, J., Loraas, T., & Mueller-Phillips, J. (2014). Online instrument delivery and participant recruitment services: Emerging opportunities for behavioral accounting research. *Behavioral Research in Accounting*, *26*(1), 1–23. https://doi.org/10.2308/bria-50651

Briesemeister, B., Kuchinke, L., & Jacobs, A. (2012). Emotional valence: A bipolar continuum or two independent dimensions? *SAGE Open*, *2*(4), 1–12. https://doi.org/10.1177/2158244012466558

Capstick, S., Pidgeon, N., Corner, A., Spence, E., & Pearson, P. (2016). Public understanding in Great Britain of ocean acidification. *Nature Climate Change*, *6*(8), 763–767. https://doi.org/10.1038/nclimate3005

Ceurvorst, R., & Needham, M. (2012). Is "acceptable" really acceptable? Comparing two scales for measuring normative evaluations in outdoor recreation. *Leisure Sciences*, *34*(3), 272–279. https://doi.org/10.1080/01490400.2012.669697

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences*. Erlbaum.

Cooke, S., & Kim, S. (2018). Exploring the "evil twin of global warming": Public understanding of ocean acidification in the United States. *Science Communication*, *41*(1), 66–89. https://doi.org/10.1177/1075547018821434

Dean, A., Church, E., Loder, J., Fielding, K., & Wilson, K. (2018). How do marine and coastal citizen science experiences foster environmental engagement? *Journal of Environmental Management*, *213*, 409–416. https://doi.org/10.1016/j.jenvman.2018.02.080

Dolan, R. (2002). Emotion, cognition, and behavior. *Science*, *298*(5596), 1191–1194. https://doi.org/10.1126/science.1076358

Eagly, A., & Chaiken, S. (1993). *The psychology of attitudes*. Harcourt Brace Jovanovich.

Ekman, P., & Friesen, W. (1971). Constants across cultures in the face and emotion. *Journal of Personality and Social Psychology*, *17*(2), 124–129. https://doi.org/10.1037/h0030377

Fairchild, T., Fowler, M., Pahl, S., & Griffin, J. (2018). Multiple dimensions of biodiversity drive human interest in tide pool communities. *Scientific Reports*, *8*(1), 15234. https://doi.org/10.1038/s41598-018-33155-x

Fishbein, M., & Ajzen, I. (2010). *Predicting and changing behavior: The reasoned action approach*. Psychology Press.

Fuess, L., Eisenlord, M., Closek, C., Tracy, A., Mauntz, R., Gignoux-Wolfsohn, S., Moritsch, M. M., Yoshioka, R., Burge, C., Harvell, C., Friedman, C., Hewson, I., Hershberger, P., & Roberts, S. (2015). Up in arms: Immune and nervous system response to sea star wasting disease. *PLOS One*, *10*(7), e0133053. https://doi.org/10.1371/journal.pone.0133053

Gould, R., & Lincoln, N. (2017). Expanding the suite of cultural ecosystem services to include ingenuity, perspective, and life teaching. *Ecosystem Services*, *25*, 117–127. https://doi.org/10.1016/j.ecoser.2017.04.002

Grose, S., Pendleton, L., Leathers, A., Cornish, A., & Waitai, S. (2020). Climate change will re-draw the map for marine megafauna and the people who depend on them. *Frontiers in Marine Science*, *7*, 547. https://doi.org/10.3389/fmars.2020.00547

Guest, H., Lotze, H., & Wallace, D. (2015). Youth and the sea: Ocean literacy in Nova Scotia, Canada. *Marine Policy*, *58*, 98–107. https://doi.org/10.1016/j.marpol.2015.04.007

Harvell, C., Montecino-Latorre, D., Caldwell, J., Burt, J., Bosley, K., Keller, A., Heron, S., Salomon, A., Lee, L., Pontier, O., Pattengill-Semmens, C., & Gaydos, J. (2019). Disease epidemic and a marine heat wave are associated with the continental-scale collapse of a pivotal predator (Pycnopodia helianthoides). *Science Advances*, *5*(1). https://doi.org/10.1126/sciadv.aau7042

Hewson, I., Button, J., Gudenkauf, B., Miner, B., Newton, A., Gaydos, J., Wynne, J., Groves, C., Hendler, G., Murray, M., Fradkin, S., Breitbart, M., Fahsbender, E., Lafferty, K., Kilpatrick, A., Miner, C., Raimondi, P., Lahner, L., Friedman, C., & Harvell, C. (2014). Densovirus associated with sea-star wasting disease and mass mortality. *Proceedings of the National Academy of Sciences*, *111*(48), 17278–17283. https://doi.org/10.1073/pnas.1416625111

Hirschberg, J., & Manning, C. (2015). Advances in natural language processing. *Science*, *349*(6245), 261–266. https://doi.org/10.1126/science.aaa8685

Izard, C. (2007). Basic emotions, natural kinds, emotion schemas, and a new paradigm. *Perspectives on Psychological Science*, *2*(3), 260–280. https://doi.org/10.1111/j.1745-6916.2007.00044.x

Jacobs, M. (2009). Why do we like or dislike animals? *Human Dimensions of Wildlife*, *14*(1), 1–11. https://doi.org/10.1080/10871200802545765
Jacobs, M. (2012). Human emotions toward wildlife. *Human Dimensions of Wildlife*, *17*(1), 1–3. https://doi.org/10.1080/10871209.2012.653674
Jacobs, M., Fehres, P., & Campbell, M. (2012). Measuring emotions toward wildlife: A review of generic methods and instruments. *Human Dimensions of Wildlife*, *17*(4), 233–247. https://doi.org/10.1080/10871209.2012.680175
Jacobs, S., Sioen, I., Henauw, S., Rosseel, Y., Calis, T., Tediosi, A., Nadal, M., Marques, A., & Verbeke, W. (2015). Marine environmental contamination: Public awareness, concern and perceived effectiveness in five European countries. *Environmental Research*, *143*, 4–10. https://doi.org/10.1016/j.envres.2015.08.009
Jacobs, M., Vaske, J., Dubois, S., & Fehres, P. (2014). More than fear: Role of emotions in acceptability of lethal control of wolves. *European Journal of Wildlife Research*, *60*(4), 589–598. https://doi.org/10.1007/s10344-014-0823-2
Jim, C., & Xu, S. (2002). Stifled stakeholders and subdued participation: Interpreting local responses toward Shimentai Nature Reserve in South China. *Environmental Management*, *30*(3), 327–341. https://doi.org/10.1007/s00267-002-2623-9
Johansson, M., Frank, J., Pedersen, E., & Flykt, A. (2012). Factors governing human fear of brown bear and wolf. *Human Dimensions of Wildlife*, *17*(1), 58–74. https://doi.org/10.1080/10871209.2012.619001
Johnston, J., Needham, M., Cramer, L., & Swearingen, T. (2020). Public values and attitudes toward marine reserves and marine wilderness. *Coastal Management*, *48*(2), 142–163. https://doi.org/10.1080/08920753.2020.1732800
Lacroix, K., & Gifford, R. (2017). Psychological barriers to energy conservation behavior: The role of worldviews and climate change risk perception. *Environment and Behavior*, *50*(7), 749–780. https://doi.org/10.1177/0013916517715296
Lee, T., Markowitz, E., Howe, P., Ko, C., & Leiserowitz, A. (2015). Predictors of public climate change awareness and risk perception around the world. *Nature Climate Change*, *5*(11), 1014–1020. https://doi.org/10.1038/nclimate2728
Lessard, S., Morse, W., Lepczyk, C., & Seekamp, E. (2017). Perceptions of whooping cranes among waterfowl hunters in Alabama: Using specialization, awareness, knowledge, and attitudes to understand conservation behavior. *Human Dimensions of Wildlife*, *23*(3), 227–241. https://doi.org/10.1080/10871209.2017.1414335
Lu, H. (2015). The effects of emotional appeals and gain versus loss framing in communicating sea star wasting disease. *Science Communication*, *38*(2), 143–169. https://doi.org/10.1177/1075547015619173
Mabardy, R., Waldbusser, G., Conway, F., & Olsen, C. (2015). Perception and response of the U.S. west coast shellfish industry to ocean acidification: The voice of the canaries in the coal mine. *Journal of Shellfish Research*, *34*(2), 565–572. https://doi.org/10.2983/035.034.0241
Manfredo, M. (2008). *Who cares about wildlife? Social science concepts for exploring human-wildlife relationships and conservation issues*. Springer-Verlag.
Manfredo, M., Teel, T., & Bright, A. (2004). Application of the concepts of values and attitudes in human dimensions of natural resources research. In M. Manfredo, J. Vaske, B. Bruyere, D. Field, & P. Brown (Eds.), *Society and natural resources: A summary of knowledge* (pp. 271–282). Modern Litho.
Manning, R., & Freimund, W. (2004). Use of visual research methods to measure standards of quality for parks and outdoor recreation. *Journal of Leisure Research*, *36*(4), 557–579. https://doi.org/10.1080/00222216.2004.11950036
Menge, B., Cerny-Chipman, E., Johnson, A., Sullivan, J., Gravem, S., & Chan, F. (2016). Sea star wasting disease in the keystone predator *Pisaster ochraceus* in Oregon: Insights into differential population impacts, recovery, predation rate, and temperature effects from long-term research. *PLOS One*, *11*(6), e0157302. https://doi.org/10.1371/journal.pone.0157302
Milfont, T., & Duckitt, J. (2010). The environmental attitudes inventory: A valid and reliable measure to assess the structure of environmental attitudes. *Journal of Environmental Psychology*, *30*(1), 80–94. https://doi.org/10.1016/j.jenvp.2009.09.001

Millennium Ecosystem Assessment (MEA). (2005). *Ecosystems and human well-being: Synthesis*. Island Press.

Miner, C., Burnaford, J., Ambrose, R., Antrim, L., Bohlmann, H., Blanchette, C., Engle, J., Fradkin, S., Gaddam, R., Harley, C., Miner, B., Murray, S., Smith, J., Whitaker, S., & Raimondi, P. (2018). Large-scale impacts of sea star wasting disease (SSWD) on intertidal sea stars and implications for recovery. *PLOS One*, *13*(3), e0192870. https://doi.org/10.1371/journal.pone.0192870

Morgan, C., & Stevens, C. (2008). Changes in perceptions of risk and competence among beginning scuba divers. *Journal of Risk Research*, *11*(8), 951–966. https://doi.org/10.1080/13669870802187691

National Aquarium. (2020). *Sea stars*. National Aquarium. https://aqua.org/explore/animals/sea-stars

Needham, M., Szuster, B., & Bell, C. (2011). Encounter norms, social carrying capacity indicators, and standards of quality at a marine protected area. *Ocean and Coastal Management*, *54*(8), 633–641. https://doi.org/10.1016/j.ocecoaman.2011.06.004

Needham, M., & Vaske, J. (2008). Hunter perceptions of similarity and trust in wildlife agencies and personal risk associated with chronic wasting disease. *Society and Natural Resources*, *21*(3), 197–214. https://doi.org/10.1080/08941920701816336

Needham, M., Vaske, J., & Manfredo, M. (2006). State and residency differences in hunters' responses to chronic wasting disease. *Human Dimensions of Wildlife*, *11*(3), 159–176. https://doi.org/10.1080/10871200600669973

Needham, M., Vaske, J., & Petit, J. (2017). Risk sensitivity and hunter perceptions of chronic wasting disease risk and other hunting, wildlife, and health risks. *Human Dimensions of Wildlife*, *22*(3), 197–216. https://doi.org/10.1080/10871209.2017.1298011

O'Connor, E., Hynes, S., Chen, W., Papadopolou, N., & Smith, C. (2020). Investigating societal attitudes toward marine ecosystem restoration. *Restoration Ecology*, *29*, e13239. https://doi.org/10.1111/rec.13239

Perry, E., Needham, M., & Cramer, L. (2017). Coastal resident trust, similarity, attitudes, and intentions regarding new marine reserves in Oregon. *Society and Natural Resources*, *30*(3), 315–330. https://doi.org/10.1080/08941920.2016.1239150

Perry, E., Needham, M., Cramer, L., & Rosenberger, R. (2014). Coastal resident knowledge of new marine reserves in Oregon: The impact of proximity and attachment. *Ocean and Coastal Management*, *95*, 107–116. https://doi.org/10.1016/j.ocecoaman.2014.04.011

Petit, J., Needham, M., & Howe, G. (2021). Cognitive and demographic drivers of attitudes toward using genetic engineering to restore American chestnut trees. *Forest Policy and Economics*, *125*, 102385. https://doi.org/10.1016/j.forpol.2020.102385

Rees, S., Rodwell, L., Attrill, M., Austen, M., & Mangi, S. (2010). The value of marine biodiversity to the leisure and recreation industry and its application to marine spatial planning. *Marine Policy*, *34*(5), 868–875. https://doi.org/10.1016/j.marpol.2010.01.009

Riley, S., & Decker, D. (2008). Risk perception as a factor in wildlife stakeholder acceptance capacity for cougars in Montana. *Human Dimensions of Wildlife*, *5*(3), 50–62. https://doi.org/10.1080/10871200009359187

Russell, J. (1980). A circumplex model of affect. *Journal of Personality and Social Psychology*, *39*(6), 1161–1178. https://doi.org/10.1037/h0077714

Sakurai, R., Jacobson, S., & Ueda, G. (2013). Public perceptions of risk and government performance regarding bear management in Japan. *Ursus*, *24*(1), 70–82. https://doi.org/10.2192/URSUS-D-12-00011.1

Samayoa, M. (2020). *Sunflower sea stars declared critically endangered on West Coast*. OPB. https://www.opb.org/article/2020/12/11/sunflower-sea-stars-critically-endangered-species

Shultz, J. (2020). *Sea stars: Wasting disease is ongoing*. Ocean Watch. https://oceanwatch.ca/howesound/wp-content/uploads/sites/2/2020/08/OceanWatch-HoweSoundReport2020-SH-SeaStars.pdf.

Siegrist, M. (2000). The influence of trust and perceptions of risks and benefits on the acceptance of gene technology. *Risk Analysis*, *20*(2), 195–204. https://doi.org/10.1111/0272-4332.202020

Sjöberg, L. (2000). Factors in risk perception. *Risk Analysis*, *20*(1), 1–11. https://doi.org/10.1111/0272-4332.00001

Sjöberg, L. (2004). Explaining individual risk perceptions: The case of nuclear waste. *Risk Management*, *6*(1), 51–64. https://doi.org/10.1057/palgrave.rm.8240172

Slovic, P. (2010). *The feeling of risk: New perspectives on risk perception*. Earthscan.

Spence, E., Pidgeon, N., & Pearson, P. (2018). UK public perceptions of ocean acidification: The importance of place and environmental identity. *Marine Policy*, *97*, 287–293. https://doi.org/10.1016/j.marpol.2018.04.006

Sponarski, C., Miller, C., Vaske, J., & Spacapan, M. (2016). Modeling perceived risk from coyotes among Chicago residents. *Human Dimensions of Wildlife*, *21*(6), 491–505. https://doi.org/10.1080/10871209.2016.1190989

Sponarski, C., Vaske, J., & Bath, A. (2015). The role of cognitions and emotions in human-coyote interactions. *Human Dimensions of Wildlife*, *20*(3), 238–254. https://doi.org/10.1080/10871209.2015.1010756

Steel, B., Smith, C., Opsommer, L., Curiel, S., & Warner-Steel, R. (2005). Public ocean literacy in the United States. *Ocean and Coastal Management*, *48*(2), 97–114. https://doi.org/10.1016/j.ocecoaman.2005.01.002

Straka, T., Miller, K., & Jacobs, M. (2019). Understanding the acceptability of wolf management actions: Roles of cognition and emotion. *Human Dimensions of Wildlife*, *25*(1), 33–46. https://doi.org/10.1080/10871209.2019.1680774

Vaske, J. (2019). *Survey research and analysis*. Sagamore/Venture.

Vaske, J., & Manfredo, M. (2012). Social psychological considerations in wildlife management. In D. Decker, S. Riley, & W. Siemer (Eds.), *Human dimensions of wildlife management* (pp. 43–57). Johns Hopkins University Press.

Vaske, J., Needham, M., Stafford, N., Green, K., & Petchenik, J. (2006). Information sources and knowledge about chronic wasting disease in Colorado and Wisconsin. *Human Dimensions of Wildlife*, *11*(3), 191–202. https://doi.org/10.1080/10871200600669981

Vaske, J., Timmons, N., Beaman, J., & Petchenik, J. (2004). Chronic wasting disease in Wisconsin: Hunter behavior, perceived risk, and agency trust. *Human Dimensions of Wildlife*, *9*(3), 193–209. https://doi.org/10.1080/10871200490479981

Vaske, J., & Whittaker, D. (2004). Normative approaches to natural resources. In M. Manfredo, J. Vaske, B. Bruyere, D. Field, & P. Brown (Eds.), *Society and natural resources: A summary of knowledge* (pp. 238–294). Modern Litho.

Wachholtz, S., Artz, N., & Chene, D. (2014). Warming to the idea: University students' knowledge and attitudes about climate change. *International Journal of Sustainability in Higher Education*, *15*(2), 128–141. https://doi.org/10.1108/IJSHE-03-2012-0025

Wann, D., & Branscombe, N. (1995). Influence of identification with a sports team on objective knowledge and subjective beliefs. *International Journal of Sport Psychology*, *26*(4), 551–567.