Steller Sea Lion (*Eumetopias jubatus*) Response to Non-lethal Hazing at Bonneville Dam

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Protected Steller sea lions (*Eumetopias jubatus*) aggregate at Bonneville Dam on the Columbia River and prey upon multiple species of endangered salmon ascending the river. Hazing is a non-lethal activity designed to repel sea lions that includes aversive auditory and physical stimuli to deter animals from an area and has been employed with sea lion—fisheries interactions for more than 40 years but sea lion responses to hazing through time is not well-documented. We observed the behavior of Steller sea lions in periods with and without hazing during two spring Chinook salmon passage seasons to evaluate: (1) what effect hazing had on the number of animals present and their foraging behavior, and (2) whether they habituated to hazing. We found that hazing temporarily reduced the number of Steller sea lions, but only when actively hazed. During hazing, Steller sea lions were more likely to move away from hazers on the dam, decreased their foraging, and increased their time investigating the environment. However, these effects were temporary; their behavior returned to initial observation levels once hazing ceased. Furthermore, their responsiveness to hazing declined throughout the season, indicating habituation and raising concern for the application and long-term efficacy of hazing in managing predation on endangered salmon.

Keywords: Columbia River, *Eumetopias jubatus*, habituation, hazing, human-wildlife conflict, non-lethal deterrence, Steller sea lion

INTRODUCTION

The Marine Mammal Protection Act in 1972 is a conservation success story, accelerating the rebound of many Pacific Northwest pinniped populations [National Oceanic and Atmospheric Administration (NOAA), 2014; NOAA, 2015; Laake et al., 2018]. However, at the same time, largely because a mix of human development (Sobocinski et al., 2018; Cline et al., 2019), habitat destruction (Feist et al., 2003), and over-fishing (PFMC, 2016), 13 species of Columbia River salmon and steelhead have crashed and are now threatened or endangered (NMFS, 2019). An unintended consequence of pinniped recovery is that pinniped populations increasingly prey on endangered salmon (Schakner et al., 2016; Chasco et al., 2017). For more than 40 years, wildlife managers in the Pacific Northwest have sought to alter the foraging behavior of sea lions near impoundments to protect salmon runs. In the late 1980s, California Sea Lions (CSL, *Zalophus californianus*) predation significantly reduced endangered winter steelhead (*Oncorhynchus mykiss*) at Ballard Locks near Lake Washington in Washington State (Jeffries and Scordino, 1997; Fraker and Mate, 1999).
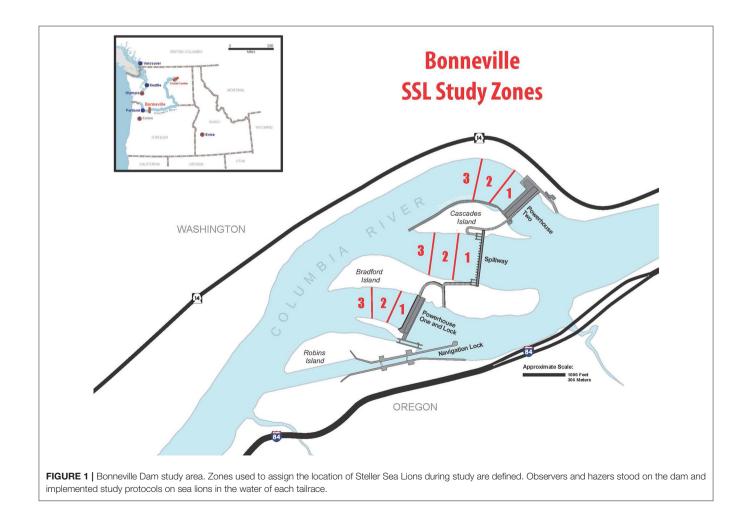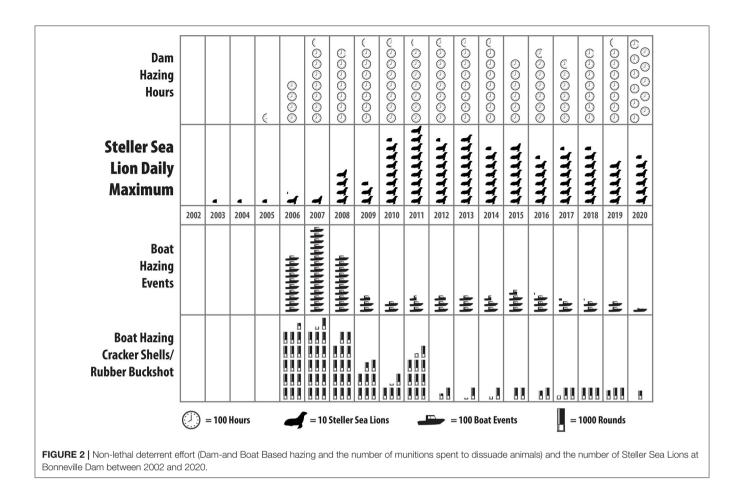
Managers responded with non-lethal and later lethal interventions, but the winter steelhead run was ultimately extirpated. A similar situation has unfolded in the Columbia River near Bonneville Lock and Dam (**Figure 1**). Sea lion predation has directly increased the risk of extinction for several endangered salmon species (NMFS, 1997).

Bonneville Lock and Dam is the first dam encountered by fish migrating upstream, located at river mile 146 (river kilometer 235). It spans the Columbia River between Oregon and Washington and consists of three concrete structures separated by islands. The structures form tailraces that guide fish to ladder entrances that facilitate passage (**Figure 1**). Thus, the dam bottlenecks fish passage (Kareiva et al., 2000; Quinones et al., 2015), concentrating the fish, making them vulnerable to predation (Naughton et al., 2011; Falcy, 2017). Since 2002, both CSLs and Steller sea lions (SSL, *Eumetopias jubatus*) have foraged on endangered salmon at Bonneville Dam (Stansell, 2004; Tidwell et al., 2020).

To comply with statutory guidance (NMFS biop), the U.S. Army Corps of Engineers initiated a program at Bonneville Dam to monitor the abundance of sea lions and the amount of predation and implement/evaluate hazing on pinnipeds at the dam. Hazing, a technique where deterrents are applied to immediately modify undesirable behavior (Schirokauer and Boyd, 1998; Hopkins et al., 2010), was initiated in 2002 with the ultimate aim of decreasing the predation on threatened salmonids as they migrate upstream. Deterrents applied at the dam include acoustic deterrent devices, paintballs, rubber shotgun projectiles, cracker shells, and seal bombs (i.e., underwater pyrotechnics) and physical barriers called Sea Lion Exclusion Devices that are placed on fish ladder entrances that prevent sea lion access to the fish ladders of the dam (NMFS, 2000, 2008, 2019). The combination of hazing, lethal removal, and non-lethal relocation of CSLs (over 283 lethally removed), have reduced CSL predation but created an opening for SSL at the dam. As a result, SSL are now the more abundant and persistent sea lion species near the dam (**Figure 1**, Tidwell et al., 2020).

Despite the long-term application of hazing at Bonneville, SSL behavioral response to hazing is uncertain (Scholl and Hanan, 1986; Schakner and Blumstein, 2013). Early reports from Bonneville Dam indicated that SSLs reportedly fled downstream following the initial bout of hazing. However, after repeated hazing, they fled for shorter periods and eventually remained near the dam despite hazing (Stansell, 2004; Norberg et al., 2005) (**Figure 2**). Hazing has been applied at Bonneville Dam with boats and on land from the dam's face. Evaluation of boat-based

FIGURE 1 | Bonneville Dam study area. Zones used to assign the location of Steller Sea Lions during study are defined. Observers and hazers stood on the dam and implemented study protocols on sea lions in the water of each tailrace.

FIGURE 2 | Non-lethal deterrent effort (Dam-and Boat Based hazing and the number of munitions spent to dissuade animals) and the number of Steller Sea Lions at Bonneville Dam between 2002 and 2020.

hazing of pinnipeds has been conducted at Bonneville Dam and elsewhere and deemed potentially effective at disrupting foraging but effectiveness is situationally dependent and has limited effectiveness over the long term (Lottis, 2009; Hatch et al., 2019). The declining response of SSLs to hazing stimuli indicates habituation, which is a recognized limitation of hazing with non-lethal deterrents (Schakner and Blumstein, 2013). Habituation, a non-associative learning process, exemplified by reducing responsiveness to stimulus exposure over time (Rankin et al., 2009), is frequently postulated in applied pinniped management (Geiger and Jeffries, 1987; Gearin et al., 1988) but rarely demonstrated empirically (as in Schakner and Blumstein, 2020). To test this, we exposed recurring SSL to controlled hazing periods (i.e., with and without hazing) throughout two spring Chinook passage seasons. We assessed land-based hazing exclusively because it has never been evaluated at an impoundment and is most feasible for management to apply in pinniped-fisheries interactions. We evaluated: (1) the effect of hazing on the foraging behavior of SSL near the dam and (2) whether hazing repelled individuals from the dam, and (3) whether SSL habituated to hazing stimuli. We predicted that hazing would have no impact on the number of individuals at the dam and that behavioral responses observed at the beginning of the season would diminish with subsequent hazing applications.

METHODS

Study Subjects and Duration of Study

Spring Chinook salmon pass Bonneville Dam between early March and the end of June. Managers define the run as occurring between March 15 and June 15. During these months, Chinook comprise more than 95% of the fish passage estimates. All SSLs near Bonneville Dam are adult males. The females of the species remain at the coast and near the rookeries year-round while males migrate for foraging purposes. The SSLs at Bonneville Dam forage near the dam during the fall, winter, and spring and only leave the dam in June and July to breed and return to the dam in August. Alphanumeric cattle brands identify many, and some have been observed at the dam for up to 13 years. Not all SSL in the sample were individually identified, but monitoring program data indicate that 90% of individually identifiable SSL stay at the dam for 8–10 months of the year. As the spring Chinook run increases in April and May, more SSL move upstream to forage at Bonneville Dam.

Data were collected in conjunction with the sea lion predation monitoring program, which randomly assigns 1-h blocks of observation across the dam's three tailraces during all daylight hours using a systematic random design that provides equal distribution of at least 20 percent of daylight hours across all
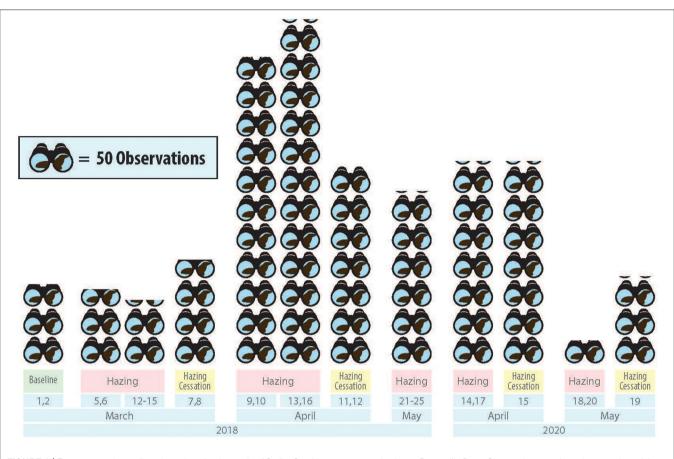
FIGURE 3 | Treatment and sampling chronology for the study of Steller Sea Lion response to hazing at Bonneville Dam. Observations are the unique number of times surface active animals were recorded for study purposes during defined observation periods.

three tailraces (Tidwell et al., 2018). Behavioral sampling for this study was conducted for 1 week each month between March 1, 2018, and May 25, 2018, and again between April 14, 2020, and May 20, 2020 (**Figure 3**; **Supplementary Table 1**). During the sample period tailraces are subject to daily manipulation of water flow for hydropower production and since SSL presence across was randomly distributed across all three tailraces it was not individually monitored.

Treatment Groups

Pinniped hazing at Bonneville Dam is conducted under the authority of Sections 101(a)(4)(A)(iv) and 109(h)(1)(C) of the MMPA, which allows federal entities to dissuade and deter pinnipeds from federal property when needed (MMPA, 1994). Continuous daylight hazing is required as part of the lethal removal authority for CSL and had to be implemented. However, NOAA approved cessation and modification of hazing on a number of specific days to evaluate hazing effects. Dam-based hazing is applied from hazing personnel located on the dam structures overlooking the tailraces. No boat-based hazing occurred during the weeks of study in 2018 or 2020.

We evaluated SSL response to hazing by contrasting their behavior in a baseline condition without hazing (termed Baseline

Treatment) to periods when hazing was applied (termed Hazing Treatment) and their behavior on days immediately following hazing (termed Hazing Cessation Treatment). Baseline observations occurred on the 2 days preceding the initiation of hazing in 2018. Of the three sampled weeks in March-May 2018 we collected data on two baseline days, 15 hazing days, and four post hazing days. In April-May 2020, we observed four hazing days and two post-hazing days (**Figure 3**).

Due to COVID-19 constraints, Bonneville Dam access was restricted in March 2020, and observers were not allowed to be present, but hazers were required to start hazing. As such, there was no sampling for the month and no baseline data were recorded in 2020.

Sampling

Five trained observers used 8×42 binoculars to monitor and sample SSL behavior in all three tailrace areas for a minimum of 1 h per sample using interval scan sampling and an ethogram. Because the mean dive time (length of time the animal is below the water's surface) for SSLs at Bonneville Dam is 6 min (Tidwell unpublished data), the observers sampled for 60 s every 3 min each hour to increase the likelihood of observing each SSL when it was at the surface. Observers recorded the data for each SSL at the

Category	State	Description
Behavior	Foraging	Animal engages in behaviors such as back-flips, underwater pursuits (Not Transit), or consuming prey. Makes multidirectional movements. When at the surface, it is breathing rapidly to recover air from previous dive and returns to diving. Time underwater > above water.
	Transit	Animal swims from one location to another with intent (i.e., mono-directional movement), this can include: porposing, swimming with head above water not foraging. When at the surface, it is breathing slowly. Time above water > time underwater.
	Rest	Animal stays in one place at either haul-out or raft.
Vigilance	Low	Animal does not look around tailrace when at the surface. It does not direct eye contact with observer. No vocalization.
	Medium	Animal occasionally looks around the tailrace when at the surface and sporadically directs eye contact toward the observer. Vocalizes occasionally.
	High	Animal frequently looks around tailrace when at the surface and directs eye contact toward the observer often. Frequently looks Vocalizes frequently.
Location	1	Dam's face—100 m downstream
	2	101–200 m downstream
	3	>200 m downstream of dam face

beginning of the 60-s observation period rather than at the end of the observation period. The number of sea lions in each sampled tailrace was recorded before every 1-h observation period. If more than one SSL was present during an observation period, observers recorded all the data for the first SSL before recording data for additional SSL. All observers had extensive experience with SSL behavior from previous years. Where possible, they recorded individual SSL IDs during behavioral observations. Observers used scan sampling to provide a general snapshot of the population's behavior rather than focal follows of identified individuals, and, in most cases, behavioral observations were not linked with individual animals.

During the observation period at each tailrace, observers categorically scored the behavior, vigilance, and location of each SSL and whether the dam-based hazing was occurring (see the ethogram in **Table 1**). Each of these variables had three possible values intended to reveal the extent to which SSLs responded to hazing.

Observers recorded the behavioral state of each individual by classifying them into three categories: foraging, traveling or resting. Animals transitioned between these states throughout the observation period; for example, if an animal was startled by a stimulus, including hazing, it might shift from foraging to traveling. These behaviors were scored based on the animal's body posture, movement pattern, and breathing intensity while at the surface. For example, an SSL was judged to be foraging

if it briefly surfaced to breathe before quickly diving again, often without exposing its dorsal surface (e.g., in a cartwheel fashion), or surfaced to breathe and used its flippers to maintain a stationary position in the water column with its dorsal surface exposed after an extended dive. A traveling sea lion was at the surface longer, moved directionally with more speed, and breathed at a slower rate. A resting sea lion was defined as being either hauled out on land or resting in a raft with other sea lions. In the Bonneville Dam tailraces, resting in a raft is rarely observed but was included to be thorough.

Vigilance was scored as low, medium, or high based on the SSL's behavior and on almost two decades of SSL observation at Bonneville Dam that suggested it was sufficient to capture the variation in response to hazing. Low vigilance (score = 1) was characterized by an animal that exhibited no response to its surrounding environment and would never vocalize. High vigilance (score = 3) was characterized by an animal that was actively assessing the environment, looking at observers, other SSLs, or tailrace objects. The animal would actively look toward observers and vocalize often. Medium vigilance (score = 2) was a moderate expression of vigilance, and was characterized by an animal that occasionally vocalized or looked toward observers, but did not spend most of the surface active time investigating or vocalizing. Vigilance was scored independently of behavioral state, that is, animals could be foraging with high vigilance or traveling with high vigilance.

Location data were collected to assess how hazing might change SSL proximity to the dam. Location was characterized by defining three zones based on distance from the dam (**Figure 1**). Zone 1 was nearest the dam and is where the majority of SSL foraging occurs (Tidwell et al., 2018). Therefore, because hazing occurs from the dam and is nearest to Zone 1, animals that are more readily dispersed are expected to spend more time in Zone 2 or 3 than would otherwise be the case.

Continuous variables recorded included: date, number of pinnipeds present, and type of hazing. To assess how hazing might alter behavior over time we noted the number of hazing treatments (we refer to this as hazing number). For example, in March there were two Hazing Treatments, followed by a Hazing Cessation Treatment, then a third Hazing Treatment. We scored the third Hazing Treatment as Hazing Number = 3.

Statistical Analysis

For all statistical analyses, we used R 2.14 (R Development Core Team, 2014). The factors influencing the number of SSL present were analyzed using a generalized linear model (GLM) with a Poisson distribution and a log-link function. The following predictor variables were included in the "full" model structure; Hazing (presence/absence), date, year, as well as the interaction between hazing by zone interaction (**Table 2**). We compared models with different degrees of complexity and interpreted the estimates in the one with the lowest Akaike information criterion AIC value (**Table 2**—Burnham and Anderson, 2002).

To study factors that predicted SSL behavior (Foraging vs. Traveling), we fitted GLMs with a binomial distribution. The following predictor variables were included in the "full" model structure (**Table 1**): treatment type (Baseline, Hazing, and Hazing

TABLE 2 | Models that were evaluated during model selection.

Dependent variable (response)	Model	Factor combinations (predictors)	Δ AIC
Number of individuals	Poisson distribution with log-link function	Hazing, year, date, hazing number*zone	0
		Hazing, year, date	1.66
		Hazing, year	4.76
		Hazing	98.74
Proportion of individuals Foraging vs. transiting	Binomial	Treatment, # SSL present, year, treatment*Hazing number	0
		Treatment, # SSL present, year,	8.45
		Treatment, # SSL present, year, Hazing number	53.95
		Treatment, # SSL present, Hazing number	24.526

Cessation), year, hazing number, and number of SSL present, as well as the interaction between hazing number and treatment. Again, we compared models with different degrees of complexity and used AIC to identify the most efficient model.

Significance was assessed using confidence intervals (C.I.s, 95%) calculated with the "confint" function (method "Wald") in lme4. Model assumptions were evaluated based on the distribution of residuals and quantile-quantile plots and by plots of residuals vs. fitted values ("DHARMa," Florianhartig, 2019). All model parameter coefficients and C.I.s are shown on the scale of the response variable.

The factors affecting SSL vigilance were analyzed using an ordinal logistic regression model [Polr model function of MASS package (Venables and Ripley, 2007)]. This approach was chosen because of the discrete ordered nature of observed vigilance categories (**Table 1**). For this analysis, we used discrete vigilance categories low, medium and high as the response variable and treatment, number of SSL, year, Hazing number and Hazing number * treatment interaction as predictors. For the ordered logistic regression, the odds ratio (OR) and 95% confidence intervals are shown on the scale of the response variable. Model fit and diagnostics were validated using surrogate residuals calculated in the R package "sure" (Greenwell et al., 2017).

RESULTS

In 2018 and 2020, we conducted 28 days of sampling and recorded 3,289 observations of SSL behavior during the various treatments (**Figure 3**). The number of SSL recorded ranged from 1 to 10 SSL with an average of 5.3 in 2018, and from 2 to 10 SSL with an average of 4.9 in 2020. In 2018 we observed a single animal resting and elected to exclude this from further analysis because its rarity at the Bonneville Dam.

We found that hazing reduced the overall number of SSL and altered their distribution (**Table 3**). The model predicted a 31 percent decrease in the number of SSL during the (**Table 3**). The interaction term of Hazing and Zone predicted a 47 percent increase in the number of SSL in Zone 3 (i.e., further away from the dam) during hazing. However, this effect appears temporary because date was marginally significant, indicating a trend toward increasing in the total number of animals in the observation area throughout the sampling period. In general

TABLE 3 | General linear model predicting the factors influencing the number of SSL present at Bonneville during observation.

Variable	Coefficient	CI (95%)	*P*-value
Model response variable: number of sea lions present			
(Intercept)	5.9	5.37, 5.68	**<0.005**
Date (Day)	**1.00**	**1.00, 1.004**	**0.01**
Hazing	**0.69**	**0.66, 0.72**	**<0.001**
Year (2020)	**0.82**	**0.80, 0.88**	**<0.001**
Zone 2	**1.12**	**1.06, 1.16**	**<0.001**
Zone 3	0.93	0.83, 1.04	0.30
Hazing * Zone 2	0.95	0.87, 1.04	0.45
Hazing * Zone 3	**1.47**	**1.3, 1.72**	**<0.001**

Model coefficients presented on the scale of the response variable (Number of sea lions present). Significant (p < 0.05) variables are highlighted in bold.

more animals were predicted in Zone 2. Year was also significant, there were on average 18 percent fewer individuals at the dam during the 2020 field season, compared to 2018.

We found that the proportion of animals that are foraging relative to transiting changed with treatment type, the number of SSL, year, and the interactive effect of hazing and Hazing number. The application of the Hazing Treatment reduced SSL foraging and predicted an eight-fold increase in observations of SSL traveling (**Table 4**) which was not seen during the Baseline and Hazing Cessation treatments. Moreover, we found a significant, positive interaction between Hazing Treatment and Hazing number with behavior. Thus, with each subsequent application of the Hazing Treatment we found SSL were less likely to respond by traveling, and more likely to forage (**Table 4**). We also found a positive correlation between foraging behavior and the number of animals present. Year was also significant, with increased foraging behavior observed in the 2020 sampling season compared to 2018.

We found vigilance varied with Hazing Treatment, Year, hazing number, and the interactive effect of Hazing Treatment and hazing number (**Table 5**). The application of the Hazing Treatment predicted a three-fold increase in vigilance. However, this was not seen for the Hazing Cessation Treatment, thus vigilance appears to return to Baseline during the Hazing

	Model coefficient	CI (95%)	P-value
Model response variable: proportion of individuals foraging vs. transiting behavior			
(intercept)	**0.05**	**0.02, 0.12**	**<0.001**
Treatment: Hazing	**8.3**	**4.25, 22.0**	**<0.001**
Treatment: Cessation	1.90	0.72, 4.90	0.22
Year (2020)	**0.57**	**0.54, 0.91**	**0.01**
Hazing number	1.04	0.81, 1.35	0.59
Total animals present	**1.11**	**1.07, 1.15**	**<0.001**
Hazing Treatment * hazing number interaction	**0.65**	**0.50, 0.85**	**<0.001**

Model coefficients presented on the scale of the response variable (Foraging behavior). Significant (p < 0.05) variables are highlighted in bold.

TABLE 5 | Model estimates of the ordinal logistic regression model for factors predicting Vigilance behavior.

	OR	P	CI
Model response variable: vigilance behavior of SSL			
Hazing number	**1.36**	**<0.001**	**1.14, 1.61**
Treatment: Hazing	**3.81**	**<0.001**	**2.19, 6.60**
Treatment: Cessation	1.34	0.37	0.70, 2.52
Year (2020)	**0.65**	**<0.001**	**0.51, 0.77**
Hazing number * Treatment Hazing	**0.76**	**0.003**	**0.64, 0.91**

Reference level: low vigilance, OR, Odds Ratio; CI, confidence interval. Significant effects are shown in bold.

Cessation Treatment (**Table 5**). Moreover, we found a significant interaction between Hazing Treatment and hazing number, thus with each subsequent exposure to hazing, vigilance was reduced by nearly 25%. Additionally, year was significant, implying overall vigilance among the population was lower in the 2020 sampling season, compared to 2018.

DISCUSSION

For more than 40 years, wildlife managers in the Pacific Northwest have sought to alter the foraging behavior of sea lions near impoundments to reduce predation on protected salmon runs (Geiger and Jeffries, 1987; Jeffries and Scordino, 1997). By experimentally manipulating hazing throughout two spring Chinook salmon passage seasons, we were able to evaluate the effect of hazing on SSL behavior. We found hazing altered SSL behavior at the onset of the study, but the duration of effect was limited and returned to baseline measures equivalent to no hazing during the 3 months of study. Specifically, during the beginning of the spring Chinook run (i.e., in March), SSL were more likely to: move away from the face of the dam, leave the area being hazed, transit more than forage, and engage in increased vigilance. However, these effects were ephemeral; behavioral responses of both foraging and vigilance returned to initial observation levels immediately after hazing ceased. Additionally,

by the end of the spring Chinook run (i.e., by May), despite 3 months of hazing, we found no difference in responsiveness to hazing from the initial observations. This pattern occurred in both years of study. From this, we conclude that hazing failed to fundamentally change the longer-term number and distribution of SSL or disrupt foraging behavior as the season progresses.

While habituation has long been hypothesized to underlie the lack of responsiveness to deterrents at Bonneville, we explicitly tested for and demonstrated habituation at the population level, as evidenced by diminished behavioral responses after repeated exposure to hazing stimuli. Habituation is rapid when there is short amount of time between exposures to stimuli (Staddon and Higa, 1996). At Bonneville, the foraging benefits from bottlenecked prey are high, resulting in motivation to forage there. Thus, if hazing initially repels animals away from the dam or reduces their foraging success, a motivation to forage may drive them back. Since the motivation to forage increases the rate at which an individual is exposed to deterrent stimuli, it accelerates habituation. Our study confirms the common observation that habituation is a common response to non-lethal hazing.

Hazing is frequently employed to mitigate a variety of pinniped/management issues but is rarely observed to change pinniped abundance, distribution, or foraging behavior (Long et al., 2015; Schakner and Blumstein, 2020). We know of only one successful application of hazing to reduce sea lion predation after hazing has stopped. In the Rogue River system on the southern coast of Oregon, CSL, SSL, and harbor seals (*Phoca vitulina*) were hazed 3 months to minimize predation fisheries. In addition to hazing, the port community restricted all positive attractants to pinnipeds. They actively deterred pinnipeds from hauling out and banned the disposal of fishing discards into the water at docks, which is known to attract sea lions and seals. This strategy successfully shifted pinniped distribution and prevented their presence around fishing over the long term (Lottis et al., 2007; Lottis, 2009). The success at Rogue river suggests that the structure of the focal area and prey concentrations largely dictate the success of the deterrent. Repellents generally work best when there are options for animals to move to a refuge, and there are few or a controlled number of positive attractants (Kemper et al., 2003; Breck et al., 2017; Gunther et al., 2018). Unfortunately, the large size of the Columbia River makes the application of many of the above deterrents difficult. Moreover, because the salmon at Bonneville Dam are especially concentrated at the dam tailrace and fish ladder entrances, it is nearly impossible to prevent animals from being attracted to such super-abundant resources, and hence, it may be impossible to successfully deter sea lions once they have arrived at the dam.

Our evaluation of hazing SSL at Bonneville Dam is consistent with previous observations and confirms that habituation underlies the waning behavioral response to hazing. At present, hazing fails to repel individuals from the dam and does not reduce SSL foraging behavior. Since hazing does not modify sea lion behavior over time, the continued application of conventional pinniped hazing intensities and techniques at Bonneville Dam raises practical issues. It draws into question whether it is useful to continue to do something that is

both costly (Scordino, 2010) and ineffective. However, since hazing is currently a required management action, further investigation might assess how altering the current schedule and intensity of hazing might reduce habituation. Moreover, if lethal management actions are taken against SSL at Bonneville Dam, future research should investigate how newly recruited, and thus naive SSL, respond to hazing to determine how quickly habituation occurs and if it can be avoided. Hazing might generally be more effective for animals before they learn the value of resources and/or become a "problem."

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

Ethical review and approval was not required for the animal study because pinniped hazing at Bonneville Dam is conducted under the authority of Sections 101(a)(4)(A)(iv) and 109(h)(1)(C) of the Marine Mammal Protection Act which allows federal entities to dissuade and deter pinnipeds from federal property when needed (MMPA, 1994). Our data were collected when federal operators were hazing sea lions under normal conditions and as such, were covered by the above provisions of the MMPA.

AUTHOR CONTRIBUTIONS

KT: conceptualization, data curation, investigation, methodology, project administration, resources, supervision, validation, analysis, writing—original draft, and writing—review and editing. BC: data curation, investigation, methodology,

project administration, validation, visualization, and writing—review and editing. DB: analysis, interpretation of results, and writing—review and editing. ZS: conceptualization, formal analysis, writing—original draft, and writing-review and editing. All authors contributed to the article and approved the submitted version.

SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fcosc.2021.760866/full#supplementary-material

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