Planning protected area networks for surfing resources

By

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ABSTRACT

Surf breaks are vital cultural resources on coastlines worldwide, but are vulnerable to myriad threats, including climate change and coastal development; as such, efforts to protect them have proliferated. Hitherto, spatial protections (e.g., marine protected areas; MPAs) have been pursued for surf breaks as single, individual reserves. This situation is comparable to the early days of biodiversity MPAs, which eventually progressed to networked reserve design, initially culminating in California's 124 networked MPAs. Here, we apply the analogy of networked biodiversity reserve design to networked reserves for surf break protection. We examine the proposition that the effectiveness of surfing resource conservation can be improved by a "networked" approach. We conclude that specific characteristics of surf breaks, including their size, type, carrying capacity, quality, value, accessibility, spacing, vulnerability, and cultural and historic significance could all be considered and balanced to yield more effective, equitable conservation outcomes.

KEYWORDS: California, coastal management, marine protected areas, surfing resources, surf breaks.

Manuscript submitted 13 March 2024; revised and accepted 30 June 2024.

Ocean ecosystems and ecosystem services are imperiled worldwide, leading to efforts to conserve biodiversity that increasingly culminate in the designation of Marine Protected Areas (MPAs) in furtherance of global targets (Boonzaier and Pauly 2016; Davidson and Dulvy 2017). Biodiversity, and the healthy, coherent ecosystems it supports, contribute meaningfully to a variety of ecosystem services (Millenium Ecosystem Assessment 2005). However, in conservation efforts, there is less focus on cultural ecosystem services (see Milcu *et al.* 2013 for review). Surfing resources are a cultural ecosystem service deriving their existence from physical interactions of ocean surface waves with seafloors and coastlines, and deriving their quality, accessibility, and value from a suite of intrinsic and extrinsic factors, including oceanographic, geographic, ecological, social, and cultural elements (Reineman 2015). Destruction or denudation of specific surfing resource sites (i.e., "surf breaks") combined with increasing recognition of global and discrete threats to surfing resources have resulted in a corresponding increase in efforts to establish protections for them (Corne 2009; Blum and Orbach 2021; Sadrpour and Reineman 2023; Orchard *et al.* 2023). Using California as a case study, this article considers the possibility of establishing networked protected areas[1] for surf break conservation.

Legal protections for surf breaks have been achieved in several countries (Orchard *et al.* 2023). New Zealand's national-level coastal policy recognizes "surf breaks of national significance" and establishes process considerations to ensure their protection (Atkin *et al.* 2019); Peru likewise created a national law establishing protections for surf breaks (Scheske *et al.* 2019); in California, the famed surf break at Malibu was protected by listing in the National Register of Historic Places (Blum and Orbach 2021). Meanwhile, non-governmental organizations are also designating spatial areas with potential for protection: Save The Waves Coalition designates "World Surfing Reserves" at significant surf breaks around the world. These reserves, while not contemporaneously accompanied by any formal governmental protections in their home countries, can justify enacting formal, legal protection; efforts to expand individual reserves into "networks" are also under way.[2] While these efforts cover a wide scope of strategies, spatially-designated protections (e.g., MPAs or other protected areas) are increasingly a focus of surf break conservation. This focus aligns with parallel efforts to recognize surf breaks as comprising physical, biological, and social-cultural elements that extend beyond the exact area wherein "wave riding" occurs (Arroyo *et al.* in prep; Manero 2023) as well as efforts investigating potential "two-fors" between surfing resource and biodiversity conservation (i.e., co-benefits; Bukoski *et al.* forthcoming; Reineman *et al.* 2021). The former effort nuances this discussion as extending beyond "marine" protected areas to also include protection of terrestrial systems and processes.[3]

In California and elsewhere, surf breaks and their surrounding ecosystems are increasingly threatened by a compounding set of threats, ranging from global climate change and sea level rise (Hemer *et al.* 2013; Reineman *et al.* 2017; Sadrpour and Reineman 2023), to regional disruption of coastal sediment supplies (Griggs and Patsch 2018), to outright destruction or other impacts from coastal management (Reineman 2016; Reiblich and Reineman 2019), to a variety of related issues, including water

1) Herein, we generally refer to these as MPAs, but recognize that protecting surf breaks from all threats (e.g., Sadrpour and Reineman 2023) requires consideration and inclusion of terrestrial spaces and marine spaces.

2) See: www.savethewaves.org/wsr/ and www.savethewaves.org/span/ (last accessed 15 December 2023).

3) For example, an explicitly marine protected area surrounding a surf break may not provide sufficient protection to riverine inputs of watershed-derived sediment or access to the shoreline from the nearest road.

quality degradation (see, e.g., Given *et al.* 2006) and coastal access disruption (Reineman and Ardoin 2017; Patsch and Reineman 2024). Yet, the values of surf breaks in California, where surfing is the official state sport (Calif. Gov. Code Ch. 2, §424.7), and the social, cultural, and economic values that surf breaks support, are quite significant, leading to recent efforts in the state to establish formal protections for them (Blum and Orbach 2021).[4]

The current trend for surfing resource reserves is analogous to that of the past century when MPAs for biodiversity conservation were implemented as uncoordinated, ad hoc, "one-offs" — a scattershot approach that was revised with California's sequential efforts to establish networked MPAs, first around the Channel Islands, and then along its whole coast (Palumbi and Sotka 2010; Botsford *et al.* 2014). These efforts, prompted by the passage of the Marine Life Protection Act (MLPA; 1999),[5] culminated in an interconnected network of MPAs, whose size, spacing, habitat types, and other attributes were designed in a science-supported, stakeholder-informed, intentional planning process (Gleason *et al.* 2010, 2013; Saarman *et al.* 2013; Kirlin *et al.* 2013; Yaffee 2020). Critical biodiversity factors, including species' ranges, habitat requirements, and dispersal strategies, as well as such economic considerations as fishing area location and accessibility, were all combined to create a statewide California MPA system whose efficacy is founded, in part, on the connectivity of any one of its individual MPAs with the surrounding MPAs up or down the coast (Scholz *et al.* 2011; Saarman *et al.* 2013).

In this article, we consider whether such a networked approach is appropriate for conservation of a cultural and recreational resource — surf breaks — and if so, what factors, analogous to those used to establish networked MPAs for biodiversity conservation, could be considered. Phrased another way, we seek to examine the proposition that the effectiveness of surfing resource conservation can be improved by a "networked," approach instead of an entirely individualized, ad hoc approach. As a case study, we focus on the State of California (USA) and develop arguments based on a variety of disciplinary themes and perspectives and drawing on equally diverse sets of published and unpublished data. We begin with a brief review of the MLPA process in California that resulted in the first true network of MPAs. Then we expand on several ecological precepts from this process to consider which analogous traits for surfing resources would lend themselves to a network-based approach to protected area planning. We conclude with recommendations for networked surfing resource protection based on the existing — and potential future — policy landscapes.

NETWORKED MARINE PROTECTED AREAS

Between 2002 and 2013, California undertook spatial planning to protect marine biological resources along its roughly 1,000 km coastline.[6] More than 10 years of academic and agency planning preceded the initiative, which was authorized by two state laws. First, the MLPA established a process for revising and expanding a network of marine protected areas — dividing the coast into smaller study regions, establishing scientific review teams, and highlighting other important considerations. The project was so tightly associated with the MLPA that the entire initiative is commonly referred to as "MLPA implementation," or "the MLPA process." Second, the Marine Managed Areas Improvement Act (MMAIA)[7] simplified California's system of Marine Managed Areas (MMAs) to seven classifications. MPAs established under the MLPA are a subset of MMAs with various use restrictions, but sharing a primary conservation focus of natural resource protection. For each MMA classification, the MMAIA establishes a clear definition, conservation objectives, and indicates which entities can designate and manage that classification. The MMAIA also defines an administrative process for accepting, reviewing, and acting upon MMA nominations.

The MLPA process has formally protected 16% of the state's coastal waters in marine protected areas (Gleason *et al.* 2013). For this successfully implemented network, and for MPAs implemented elsewhere, two key biological considerations drive protected area design: MPA size (i.e., spatial area) and MPA spacing (i.e., distance between MPAs). These have, respectively, a direct and an inverse relationship with the potential diversity they can support, such that larger preserves with smaller distances between them are more effective for conserving biodiversity than smaller preserves spaced farther apart (Moffitt *et al.* 2011).

In the case of the California MLPA's MPA design process, the impetus to increase MPA size and decrease MPA spacing in order to conserve biological resources was met with resistance from, primarily, biological resource user stakeholder groups — fishermen and coastal Native American governments and non-recognized tribes (Murray and Hee 2019; Yaffee 2020). Fishermen, in working to protect their fishing grounds from being closed to take by MPAs, generally advocated for smaller MPAs spaced farther apart (Kirlin *et al.* 2013). The two biological considerations of size and spacing are themselves predicated on ecological concepts based on ecosystem carrying capacity (larger MPAs contain more and more varied habitat and can support more and larger species) and habitat connectivity (species move around and disperse: if such dispersal can arrive in adjacent protected areas, survival increases; see Moffitt *et al.* 2011 for discussion). Socioeconomic factors pertaining to commercial and recreational fishing were also considered, including various benefits and economic yields of specific fishing areas. Of significant note, historic and cultural significance were not factors in the identification of such areas — indeed, the absence of consideration of these values in the MLPA, especially in regard to California's tribal communities, has been recognized as a "significant policy and social justice oversight" (Murray and Hee 2019 at p. 9). As a result, there was poor tribal engagement and resulting pushback in early phases of implementation; these spurred managers to develop new outreach strategies in latter phases (Sayce *et al.* 2013).

From these MLPA MPA factors, we distill several broad considerations that should be explored and balanced in networked biodiversity reserve design: size, carrying capacity, spacing, diversity, quality, value, and accessibility. In the following section, we evaluate each of these considerations in the context of surfing resources and discuss how they might be

4) See also California Assembly Bill 2177 (2022) to designate state surfing reserves.

5) Marine Life Protection Act of 1999, Calif. Fish & Game Code §§2000-2954.

6) A marine reserve network was first established around the California Channel Islands; lessons from this process were incorporated into the process design and implementation of the network that now spans the entire coast (Botsford *et al.* 2014); here we focus on the second, statewide effort.

7) Marine Managed Areas Improvement Act of 2001, Calif. Pub. Res. Code §§36600-36900.

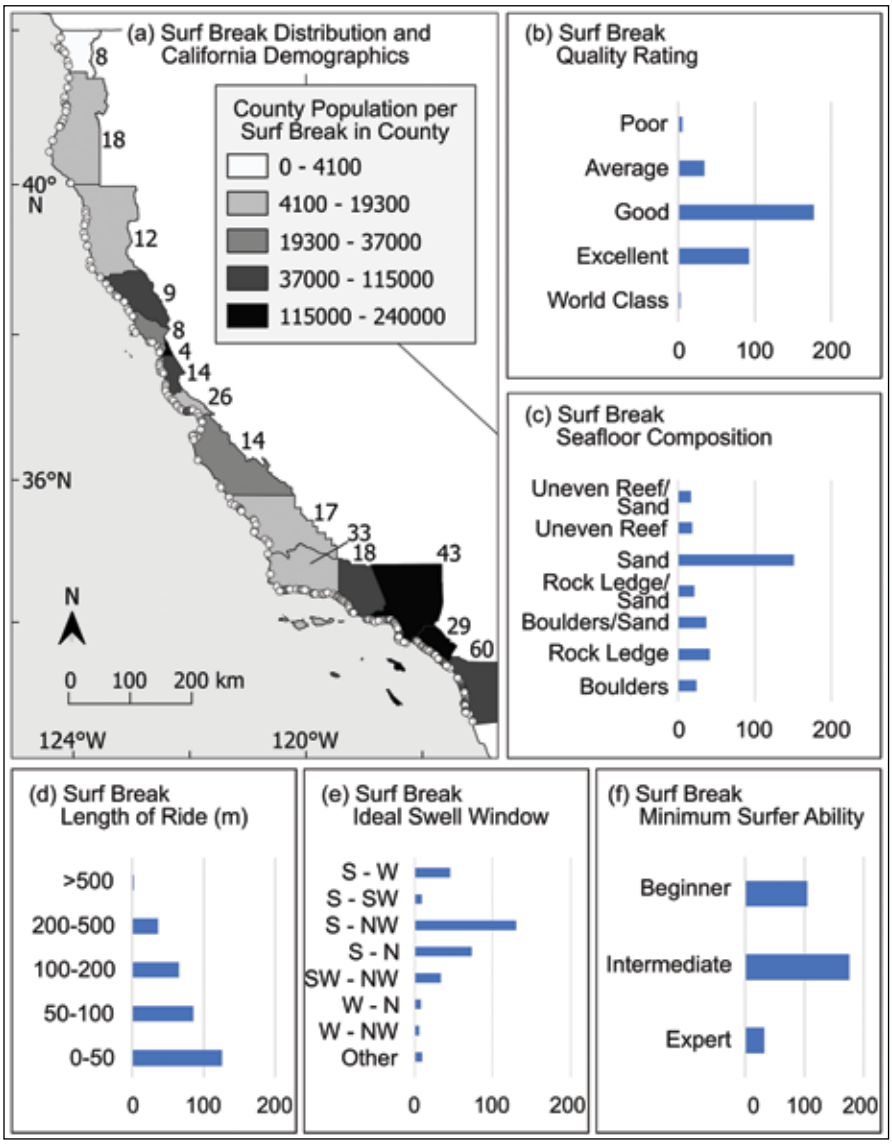

Figure 1. Surf break frequency in California. (a) Surf breaks identified along California's coast (small dots) with coastal counties shaded according to the population normalized per the number of surf breaks in that county (i.e., county population/surf breaks in county); numbers for each county are counts of surf breaks in that county; frequency histograms of California surf breaks according to their (b) quality, (c) seafloor composition, (d) typical length of ride, (e) ideal direction of origination of swell, and (f) minimum ability necessary for surfers to surf there. All data are derived from the *Stormrider Surf Guide*'s public dataset, except for county population via the U.S. Census.

considered in the design of a networked surfing reserve system. We also address two additional considerations for surf breaks: vulnerability and cultural and historical significance. Given the sensitivity of surf breaks to environmental conditions and coastal management activities, vulnerability is a critical factor; cultural and historic significance is a community-based valuation, a context for public engagement, and a pathway to ensure the values of minoritized or underserved communities are considered.

CONSIDERATIONS FOR NETWORKED PROTECTED AREAS FOR SURFING RESOURCES

Here, in analyzing key characteristics for consideration in networked surfing reserve system design, we rely on both published and unpublished data. In the case of surfing resources, these characteristics are interrelated and so we present them as follows: (1) surf break size, carrying capacity, and variety; (2) surf break quality and value; (3) accessibility and spacing; (4) vulnerability; and (5) cultural and historic significance. Our objective is not to present definitive analyses of any characteristic, but rather to use existing data to initiate debate about which types of data *could* be considered in a future planning process.

1) Surf break size, carrying capacity, variety

Waves break according to predictable, defined, physical relationships between their size, period, and direction of travel, and bathymetry of the seafloor. These factors affect wave quality (see following section) but also naturally divide surf breaks into several general categories, including breaks where the surfer may ride to the right or left or both (Butt *et al.* 2004), as well as a variety of metrics informing the circumstances of when and how a wave breaks and the attributes of the rides surfers might achieve on them. California's lengthy coastline provides tremendous variety in terms of surf break quality, length, etc.; a dataset of California surf breaks (Sutherland and Colas 2018[8]) finds that the state's roughly 300 described breaks are widely distributed across various attributes (Figure 1). According to these data, greater than 30% of California's breaks are excellent or better (Figure 1b), more than two thirds are short (rides of 100 m or less; Figure 1d), and about one third are optimal for beginners (Figure 1f); Figure 1 also displays additional attributes. As public recreational resources, surf breaks may also demand certain improvements (e.g., vehicle parking, accessibility features, restrooms; Blum and Orbach 2021); these improvements can define a community's context and value of a particular surf break and type (Atkin *et al.* 2019).

Surf break type has implications not only for diversity of resources protected and the preferences of users, but also for the size of the reserves themselves, because the spatial extent of surf breaks can vary widely: reef and point breaks, for example, rely on fixed features of bathymetry or coastal geography, whereas beach breaks rely on seafloor sediments whose qualities and location are dynamic in time and space — dynamism that can likewise affect other surf break types.[9] Figure 2 presents the general size (in terms of

8) A standalone version of the Sutherland and Colas Stormrider Surf Guide's surf break database was downloaded through a private arrangement on 20 December 2023 and used for the related analyses here. This dataset is more extensive than the published physical guide but is not publicly available at this time.

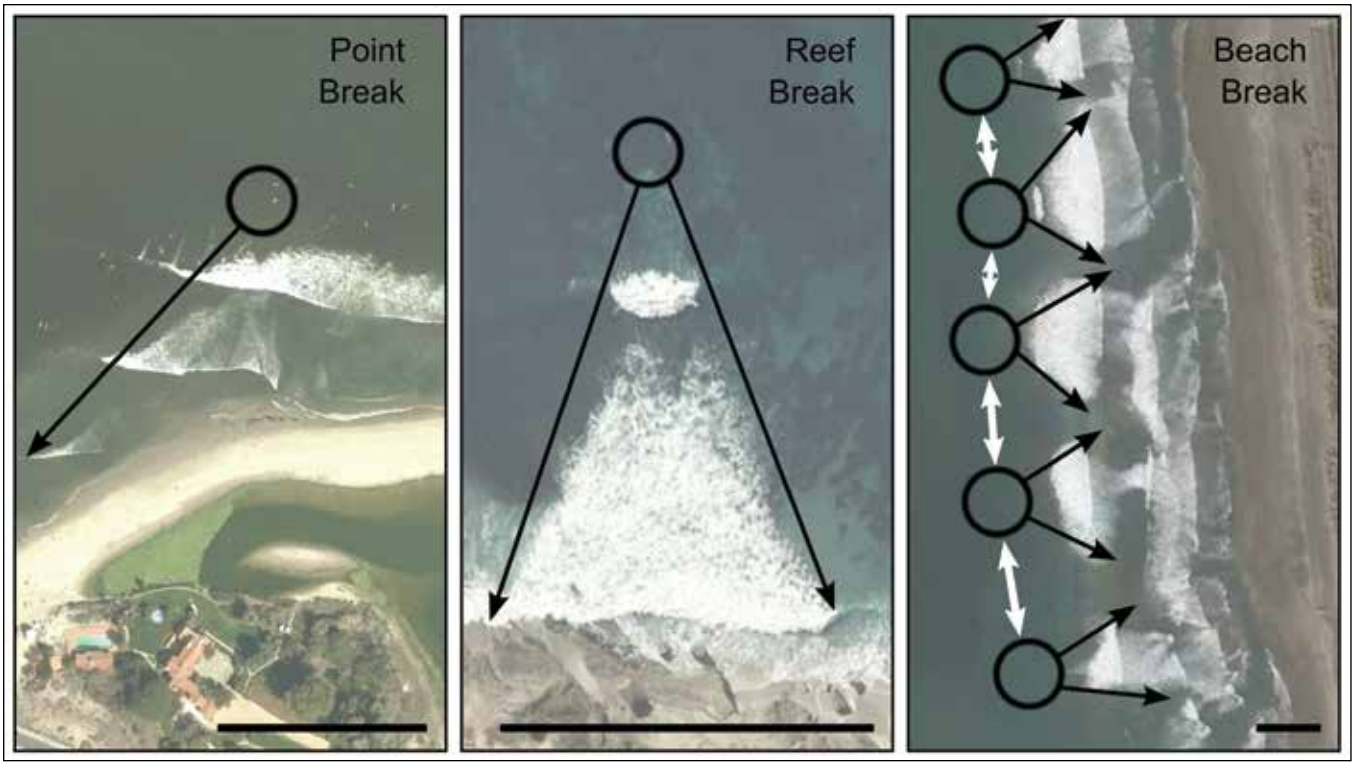

Figure 2. Surf break type and spatial characteristics. Aerial images of typical California point breaks (left), reef breaks (middle), and beach breaks (right). Circles indicate approximate "takeoff zones" (where surfers wait for and paddle to catch incoming waves) and black arrows indicate general direction of surfer motion while riding. At point and reef breaks, the location of the takeoff zones changes little depending on conditions; conversely, at beach breaks, the takeoff zones are numerous and constantly in flux due to sediment transport, as indicated by white arrows. N.B., Surfers are clearly visible floating in the water in top image. Scale bars = 100m. Images via Google Earth. Figure adapted from Reineman 2015.

area) and spatial characteristics of several representative California surf break types. Importantly, size is discussed exclusively in the context of the space where waves break and are ridden — i.e., the surf zone. However, many factors external to this space can affect the quality and existence of the wave; this point is discussed in more detail in the Discussion section.

While the natural allotment of surf break diversity is important to consider, so too is the preference of resource users — surfers. Equipment (i.e., surfboard type) as well as ability lead some surfers to develop preferences for one type of wave over another, as do long-standing relationships (i.e., tenure) with specific surf breaks, which often span decades, lifetimes, and generations (Reineman 2016; Reineman and Ardoin 2017). The preferences of California surfers, as collected in an online survey in 2014, suggest that while beach breaks are most popular, preferences for other types are widely distributed (Figure 3). Reineman and Ardoin (2017) parse surfers' different rationales for preferring one surf break over another, including both functional and symbolic reasons, such as the physical characteristics of the wave itself, its accessibility, social environment, prior personal experiences with it, and the surf break's natural environment.

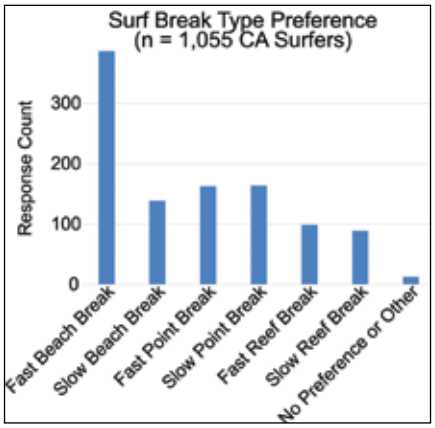

Figure 3. Surfer preferences for different surf break types in California, from a survey of surfers in 2014. These unpublished data were collected as part of a survey effort that resulted in other publications. For discussion of the methods, including the survey instrument and enumeration, see Reineman *et al.* 2017.

The carrying capacity of a surf break — how many surfers a given surf break can accommodate at one time — is also dependent on surf break type, among other factors, though the authors are not aware of specific studies purporting to develop carrying capacity measures for surf breaks; such measures have been developed for sandy beaches (see e.g., De Ruyck *et al.* 1997) and suggested for consideration in the management of, specifically, destination surf breaks (Ponting and O'Brien 2015). The authors observe, based on unpublished data and personal experiences, that some surf break types/locations (e.g., reef breaks) tend to concentrate surfers, where others tend to diffuse the crowd (e.g., beach breaks; Figure 4); furthermore, carrying capacity can vary temporally, with tide, season, and other factors shaping the quality of the surf break on hourly up to

9) For discussion, see Sadrpour and Reineman (2023); furthermore, the characteristics of any given surfing resource — especially beach breaks — may likewise rely on transport of sediment into or out of the immediate vicinity of the surf break itself through process of erosion, introduction, and translocation of sediment within coastal littoral cells (Patsch and Griggs 2006).

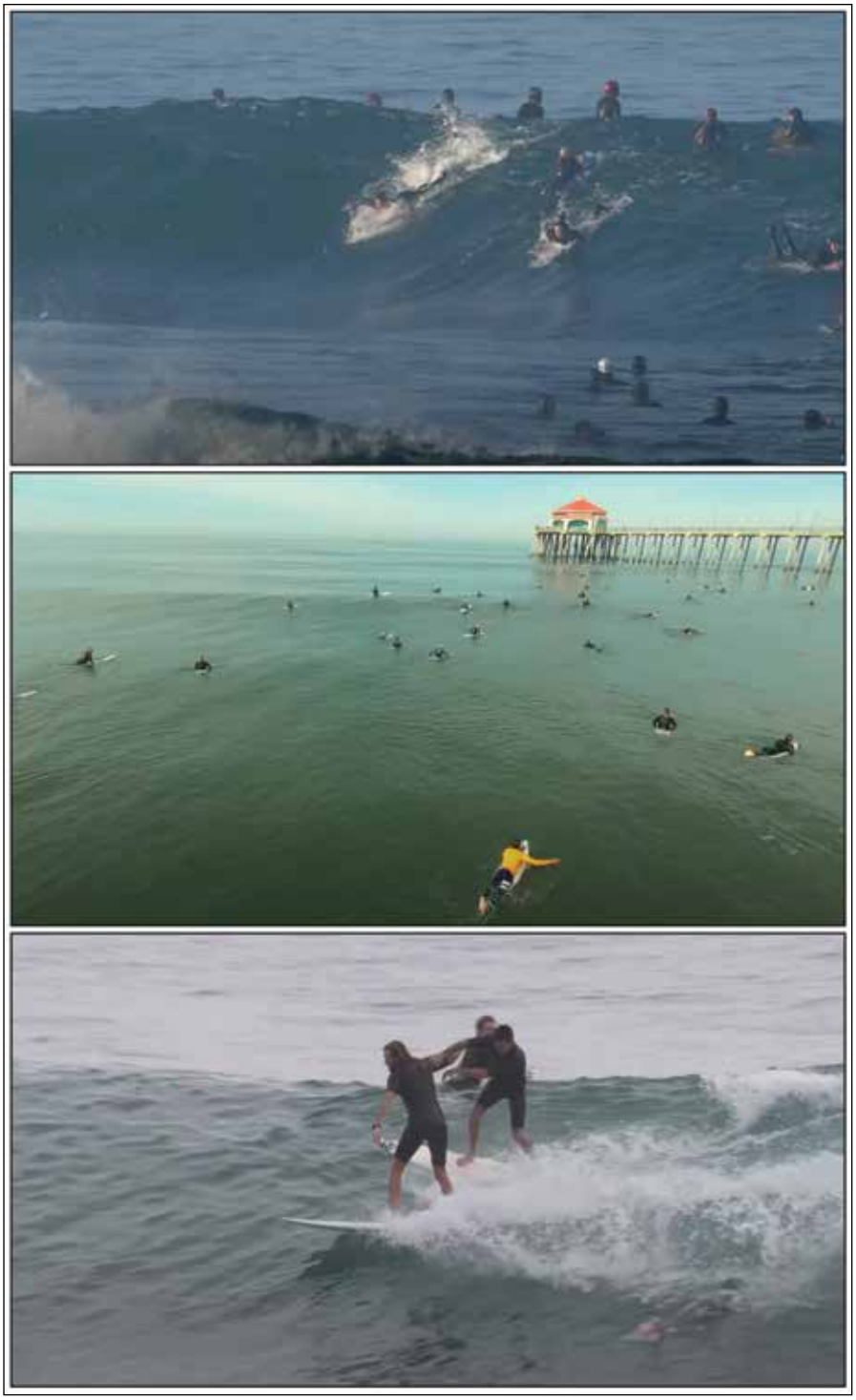

Figure 4. Surf break type affects size, carrying capacity, and — potentially — conflict. Top: A reef break in San Diego County where surfers must sit in a very confined area in order to catch a wave (YouTube frame grab from "Surfing HEAVY Slabs in San Diego January 9, 2021" at 2:22, posted by SoCal Surfer on 9 January 2021 at https://youtu.be/k20pTOotlOI). Middle: A beach break in Orange County where surfers can spread out over a large area and still catch a wave (YouTube Video Frame Grab from "The Truth About Surfing Huntington Beach" at 1:22, posted by Brad Jacobson on 29 December 2020 at https://youtu.be/tM9nSnWdVC0). Bottom: Two surfers engaged in a physical altercation for priority on a limited resource (YouTube Video Frame Grab from "Anger Management Coolangatta" at 3:57, posted by Raw Surfing on 26 May 2024 at https://youtu.be/RgrhnoP-HS4).

annual bases. Well-studied, however, are the negative interactions between surfers and the number of surfers at a surf break at one time in the form of localism and territoriality: both serve to limit resource use by others (and thereby socially reduce carrying capacity) in favor of a smaller group of surfers who claim a priority based on ability, precedence, tenure, or other factors. Kaffine (2009) and Mixon (2014) describe the relationships between surf break quality and localism in California: better quality surf breaks are more likely to experience localism-type behaviors. This phenomenon is documented elsewhere as well (Usher and Kerstetter 2015, Usher and Gómez 2016).

Summary — Surf break size, carrying capacity, variety

The type of surf break matters, both from the perspective of the resource itself, but also from the perspective of the resource user. Different types of surf breaks are not proportionally represented along California's coast (Figure 1); some are more common, some less, and each appeals to different surfers for different reasons (Reineman and Ardoin 2017). The type of surf break also has implications for its size in terms of spatial area, which is highly relevant for MPA design, and directly relevant to its carrying capacity: some breaks can easily accommodate greater numbers of surfers than others. When the number of surfers exceeds carrying capacity at a surf break, conflicts over limited resources are more likely to arise.

2) Surf break quality and value

Crowding, and subsequently conflict, are also driven by a surf break's quality, which likewise drives its value. The quality of waves varies widely in time and space *and* in the subjective opinions of surfers; several objective measures of a surf break's physical qualities, including wave peel angle and consistency, can also be identified (Mead and Black 2001). In other cases, a wave may break infrequently, but be of high repute when it does (e.g., Mavericks, a "big wave" break in California's San Mateo County). These measures, along with surfer preferences — which can draw from both personal experiences and knowledge of a surf break's reputation — combine to provide ample approaches for the assessment of surf break quality. While not a scientific metric, a Google search for "the best surf breaks in California" turns up multiple ranked lists within the

first page of search results; five California breaks are included in CNN's list of the world's 50 best breaks.[10]

A particular challenge arises in the network context with regard to surf break quality because different surf breaks are suited to different styles and levels of surfing.[11] Big wave surfing, for example, happens at a select few California surf breaks, requires specialized equipment and, due to risks and physical and technical challenges, naturally limits entry to all but extremely talented and risk-tolerant surfers (Figure 5, top). Other surf breaks, by contrast, routinely produce conditions optimal for novice surfers: peel angles are mild, waves break in a crumbling (versus barreling) fashion (Butt *et al.* 2004), bottoms are sandy and generally accessible, and longboard-style surfboards are more prevalent (Figure 5, middle). Still, many surf breaks appeal to both experienced and novice surfers, with more acute peel angles producing faster waves that support a variety of abilities and equipment (Figure 5, bottom).

Considerations of surf break quality are highly relevant to discussions of surf break value. As explained, surfers' preferences for waves vary widely, but commonly are a function of the physical attributes of a surf break and how its waves break. For example, Reineman and Ardoin (2017, p. 333) report that 670 out of 1,043 surfers surveyed (about a California surf break) mentioned "the physical characteristics of the surfed wave" when asked "[w]hy is surfing this [favorite] surf spot important to you." Other themes were not mentioned as often. Furthermore, 76.8% of the survey respondents reported surfing their favorite surf break daily or weekly (Reineman and Ardoin 2017). Thus, individual, personal significance as well as visitation frequency are two conceptual ways that waves can be valued.

Another approach used in Reineman and Ardoin (2017) was to ask respondents to describe the impacts they would suffer if their ability to surf their "favorite" surf break were permanently blocked. Although many respondents stipulated

Figure 5. Surf break quality affects surfer participation. Top: Picture of Mavericks (photo by Shalom Jacobovitz, 2010, CC BY 2.0. https://commons.wikimedia.org/wiki/File:2010_mavericks_competition.jpg). Middle: Picture of Lindamar (photo by c_nilsen, 2012, CC BY 2.0. https://www.flickr.com/photos/c_nilsen/2041391027/). Bottom: People surfing at Surfrider Beach in Malibu (photo by H. Sanchez, 2006, CC BY 2.0. https://www.flickr.com/photos/65975278@N00/236691465).

10) "World's 50 best surf spots," by Jade Bremner, for CNN, 1 July, 2013; https://www.cnn.com/travel/article/50-surf-spots/index.html (last accessed 11 December 2023).

11) "Learn To Surf: How to walk on water in 7 easy steps," by Richard Schmidt, for *Surfline*, 29 January, 2019; https://www.surfline.com/surf-news/learn-to-surf/32182 (last accessed 11 December 2023).

they would substitute their surf break for another, many respondents also described significant personal impacts. For example: "[my surf break] is a source of a large amount of my surf photography business" and "I would be angry and upset. I would feel like a part of my life was taken from me" (Reineman and Ardoin 2017 at p. 333). In some respects, an experience of loss (followed by restoration) of specific surf breaks was sustained in real life during the COVID-19 pandemic, when many beaches were closed to surfing. In a related, unpublished survey, surfers reported impacts to their mental and physical health as a result of losing access to surfing during the pandemic (Reineman, unpublished data; Usher 2023).

Alternatively, surf breaks have been assessed to determine their economic contribution to local communities. Using hedonic methods, Trestles, in southern California, was found to contribute $8 million to $13 million annually to its local economy (Nelsen *et al.* 2007); Mavericks was found to contribute $23.8 million (Coffman and Burnett 2009). There are drawbacks to these studies: they are time consuming, do not reflect other potential economic values (e.g., existence value and willingness to pay for preservation), and have been conducted at only a few surf breaks in California.

Summary — Surf break quality and value

Surf breaks can be defined qualitatively, both in absolute terms as well as relative terms. There is value in preserving various kinds of surf breaks, both expert and beginner breaks, for example. Optimally, surfers want surf breaks where they can learn basics, acquire new skills and refine ones already acquired, and, in some cases, develop expert or specialized techniques. Surfers then, through their surfing needs and preferences, come to value different waves differently, though assessing values of recreational resources is challenging.

3) Surf break accessibility and spacing

Other elements of surfing resource quality are extrinsic to the waves themselves, but extremely relevant when considering a networked surfing reserve system. These extrinsic elements pertain to the ability of the surfing public to physically visit a surf break (factors include, among others, parking, accessibility, availability of showers or other improvements, etc.), as well as to how surf breaks are distributed along California's lengthy coastline in relation to surfers' travel and visitation patterns. Spacing has been identified as a desirable feature in prioritizing surf breaks for conservation at the global scale, providing surfers with a suite of options over relatively short distances (Arroyo *et al.* 2023).

In their 2017 study, Reineman and Ardoin report that the most common theme among survey respondents describing their favorite wave — after the characteristics of the wave itself (discussed above) — was the wave's accessibility; this included mentions of proximity to such "ease of access and visitor-serving amenities as parking or showers" (p. 331). However, Wagner *et al.* (2011) report that surfers do not generally live near the surf breaks they frequent most, and, furthermore, that typical travel distances vary in different locales and for different surf breaks based on the distribution of surf breaks and surfers. California surfers drive an average of 8 miles to get to the surf (versus the national average of 10 miles; n = 2,315), but this varies from 5 miles in San Diego County, to 15 miles in the San Francisco Bay Area, to 25 miles for the surf breaks located at San Onofre State Beach (also San Diego County; Wagner *et al.* 2011).

Finally, consideration of driving distances necessitates considerations of equity and environmental justice regarding access to coastal resources. In California, due to a host of historic and contemporary factors, including, but not limited to, systematic, structural racism, segregation, and other practices, such as redlining, not all Californians enjoy equitable coastal access (Reineman *et al.* 2016) Further, while the California Coastal Act has protected the coast and access to it in many ways, the act has yet failed to achieve equitable access statewide. The population of Californians with the most access to the coast, i.e., those living within 1 km of it, has a larger white population (by 25%) and smaller populations of Hispanic or Latino people (by 52%), Black people (by 60%), American Indian people (by 58%), and households below the poverty line (by 18%), compared to the state average demographics (Reineman *et al.* 2016).

Summary — Surf break accessibility and spacing

Surf breaks are numerous but distributed unevenly across California's coast; surfers in different regions already drive a wide range of distances to reach their typical surf spots; it is possible that based on broad demographic trends, these distances are shorter for white surfers compared to surfers of color. All could be considered when determining the optimal (or minimum or maximum) distance between surfing reserves in a reserve network.

4) Surf break vulnerability

When considering whether a surf break should be protected, we can also consider whether it is acutely vulnerable and therefore would benefit from protection. We do not here purport to stipulate the goals and objectives of a potential network of surf break protected areas; we can, however, examine data suggesting that surf breaks are at risk from a variety of impacts and that some breaks are more vulnerable than others. The notion that some places or resources are less valuable or beyond saving culminates in "sacrifice zones," with attendant implications for environmental justice (Juskus 2023); from a practical standpoint, it is relevant to ask whether including in a reserve network a node (i.e., individual reserve) that cannot be saved and will soon vanish is the best allocation of a finite number of such nodes.

Several studies have examined the impacts of coastal development, climate change, and other factors on the quality and existence of surf breaks. In a review of 30 coastal development projects worldwide, Corne (2009) found that 18 suffered a reduction in the quality of their waves, while 12 experienced an improvement or no effect. In California, surf breaks are indeed vulnerable to impacts from such projects: notably, an Orange County surf break, "Killer Dana," was completely eliminated by the construction of the Dana Point Harbor breakwater in 1969 (Westwick and Neushul 2013). In contrast, the construction of the Newport Harbor north jetty created the surf break known as "the Wedge" (Orange County). As a result of these and other potential impacts, guidelines for consideration of surf breaks in planning processes to reduce their vulnerability to coastal development have been developed in New Zealand (Atkin *et al.* 2019). These guidelines have been examined with

an eye toward their adaptability to the California context (see Atkin *et al.* 2020) though they have not been adopted.

Climate change presents a suite of additional threats to surf breaks, including changes to the size and origin of wave-generating storms, alteration or destruction of coastlines, disruption of coastal processes, and sea level rise (SLR) (Sadrpour and Reineman 2023). In their review, Sadrpour and Reineman (2023) conclude that of these threats, some are existential and/or will be obviously observable to contemporary surfers in their lifetimes: they classify these as "first order," and include rapid SLR and increased magnitude and frequency of extreme events. They also include, as first order threats, human responses (e.g., coastal armoring or development), that can potentially irreparably harm surf breaks. Attempts to specifically identify climate change risks for specific surf breaks are rare in the literature; one effort to evaluate SLR impacts reported that the best conditions at greater than one-third of evaluated California surf breaks would be threatened or endangered with only 1 m of SLR (Reineman *et al.* 2017; Figure 6). A tool for assessing the key factors driving surf break vulnerability to climate change has been published (Sadrpour and Reineman 2023) and could be beneficial in identifying risks and vulnerability across the variety of California surf breaks.

Summary — Surf break vulnerability

Surf breaks are vulnerable to a suite of emerging and established threats, from human-caused threats like coastal development to impacts from climate change. While California's surf breaks have not all been individually evaluated, such evaluations are possible in principle and could inform efforts to identify surf breaks that are especially susceptible to loss or, alternatively, are not worth protecting.

5) Surf break historic and cultural significance

Lastly, sites of outdoor recreation, like surf breaks, are more than biophysical features: they represent loci of human connection to the natural environment (Peryman and Orchard 2013; Skellern *et al.* 2013; Reineman and Ardoin 2017; Blum and Orbach 2021). Such places are critical for gathering and interaction, and for producing culture, history, and outputs like economic activity (Preston-Whyte 2002, Blum 2015, Blum and Orbach 2021). As mentioned, several California surf breaks are recognized within surfing's worldwide community for their importance to the sport's culture and history.[12] Cultural and historic importance can also exist within smaller geographies. For example, a surf break may be important within a regional community for its contributions to patterns of coastal development, local recreation, or its association with important persons (Ball 2015, Blum and Orbach 2021). As a set of public policy instruments, historic preservation can perform cultural analysis of outdoor recreation landscapes to evaluate their significance (Kirk and Palmer 2006, Blum and Orbach 2021, Flynn *et al.* 2024). This investigative process is time intensive and might involve various data types, including but not limited to maps, historic documents, oral histories, and other forms of testimony. It has yielded positive results for one surf break, a renowned point break in Malibu, California (Los Angeles County), which was listed in the National Register of Historic Places (Blum and Orbach 2021).

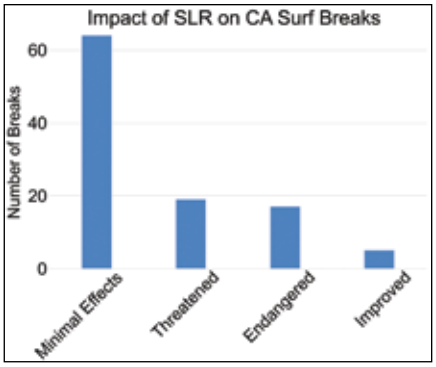

Figure 6. Effects of sea level rise on California surf breaks. The best conditions at greater than one-third (34%) of breaks are threatened or endangered with drowning due to 1 m of SLR; 61% will experience minimal effects; 5% may experience their optimal conditions more frequently. Data adapted from Reineman *et al.* 2017, Figure 4 at p. 187.

Significant surf breaks may be adjacent to, or within, lands or waters significant to other communities, including tribal communities. The proposed destruction of a tribal sacred site was one reason cited by the California Coastal Commission for denying a major construction project, thereby indirectly protecting a nearby significant surf break (Gilio-Whitaker 2012). Furthermore, as discussed, the failure to consider historic and cultural factors in consultation with tribes in California is considered an oversight of the MLPA process (Murray and Hee 2019) that has implications for stakeholder engagement and support of the planning process (Sayce *et al.* 2013). Thus, the analysis of historic and cultural significance can achieve limited surf break protection, directly involve minoritized communities, like tribes, as well as result in additional benefits for fostering public participation, process and policy update, and eventual effectiveness of established reserves.

12) See, e.g., California Assembly Bill 1782 (2018).

DISCUSSION

Surf break protection policy

In policymaking, currently, there is limited consideration of surf break protection. However, there is potential for increased consideration and formal protection of California surf breaks by engaging local, state, and federal policy instruments. Apart from Malibu's National Register listing (which requires *some* formal consideration in future planning processes that might impact Malibu), other legally protected areas, like MPAs, do not exist for any California surf breaks. As recreational resources, surf breaks receive some consideration in formal planning processes in California, particularly within the purview of the California Coastal Commission. The commission is statutorily responsible for balancing marine recreation with other activities, and it oversees implementation of local-level planning in coastal cities and counties (through Local Coastal Plans: LCPs), though the commission retains jurisdiction of regulation over activities on or adjacent to the shoreline (Atkin *et al.* 2020; Blum and Orbach 2021). Comprehensive surf break protection depends upon both access to the shoreline and protection of landside resources that influence surf quality (Reiblich 2013, Blum and Orbach 2021). LCPs, while locally crafted (and subject to approval by the commission), have jurisdiction limited to areas above mean high tide but can affirm a community's connections to local surfing resources and prioritize provision or protection of access to them. In principle, LCPs can also highlight coastal areas important to a surfing resource's quality. For example, an LCP can highlight the importance of sediment flows from a river mouth, and therefore its surround-

ing watershed system, to the quality of specific surfing areas.

With its focus on a spatial planning process to protect marine biological resources by designating networked MPAs, California's MLPA can serve as a model for future policies to create a networked surf break protection system in California. Such policies could align with the MMAIA's existing classification system, which includes two reserve types to protect marine *cultural* resources: State Marine Cultural Preservation Areas, for historic or cultural sites and objects; and State Marine Recreational Management Areas, for sites of high-value recreation. At present, there are no designated cultural resource MMAs in California, and thus there are no surfing-specific MMAs. However, marine cultural resource conservation is an available option for surf break protection; the precedent of using MPA classifications within the MMAIA to establish networked protection for marine biodiversity resources suggests a path for surfing resources.

Historic preservation, as a set of planning tools with corresponding planning protections, is a cooperative program between federal, state, and local governments. At the federal level, and as mentioned for Malibu, the National Register is already a demonstrated viable option — at least for those surf breaks satisfying the two-part requirement of historic significance, within one or more contexts, and historic integrity (Blum and Orbach 2021). While related historic resources can be networked by proximity (as historic districts[13]) or thematically (through a Historic Context Statement[14]), a programmatic approach for California's entire coastline, capturing the variety of its surf breaks, seems an unlikely pathway for a statewide protected surf break network. However, regionally scaled projects may be viable. Importantly, National Register listings secure only limited protections. In California, federal undertakings (projects funded or licensed, permitted, or approved by a federal agency) or state projects that may threaten a listed historic resource must consider potential unintended or negative effects, and, if possible, avoid them.[15] This administrative review, sometimes described as a "Stop, Look, and Listen" approach, does not guarantee that negative effects are ultimately avoided, only that they are considered during planning. However, thousands of National Register-listed properties have avoided permanent alteration or demolition through application of this process (Barras 2010). Also, these protections are neither prescriptive nor absolute: a National Register listing does not secure mandates to address standing impairments and listing protections can be discontinued if a resource is permanently altered (Blum and Orbach 2021).

Regardless of the policy mechanism pursued, the historic and cultural significance of surf breaks can still be included as factors in their selection for protected status. We do not treat these factors as extensively as we do other categories, for several reasons. First, by taking biodiversity MPAs as our analogy, our focus is on the physical resource itself and on the resource users (by analogy, ecosystems with fisheries and fishers). However, as evidenced by the MLPA planning process, a narrow focus on the physical resource alone can result in challenges to implementation and discount important connections people have made, and maintain, with coastal areas. Second, from an evaluative standpoint and in the context of this article, ready sources of data on cultural and historic significance of surf breaks are more challenging to identify and incorporate, though that does not belie their importance. California's MPA management agency, the Department of Fish and Wildlife, lists as a long-term priority recommendation in its Decadal Management Review Report the goal to "better incorporate marine cultural heritage into the design of the MPA Network."[16] While other factors (e.g., quality or popularity) might partially explain certain elements of cultural or historic significance of surf breaks, limiting evaluation to these measures would likely overlook important nuance, further disenfranchise minoritized communities, and cause eventual problems with implementation.

13) National Register Bulletin 15b. 1997. "How to apply the National Register criteria for evaluation." U.S. Department of Interior, Washington, DC.

14) National Register Bulletin 16b. 1999. "How to complete the National Register Multiple Property Documentation Form." U.S. Department of Interior, Washington, DC.

15) National Historic Preservation Act of 1966. 54 U.S.C. §§300101-320303.

16) Calif. Dept. of Fish and Wildlife, 2023. "Marine Protected Area Decadal Management Review Report: Prioritized Recommendations." https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=213111 (last accessed 4 June 2024).

CONCLUSION

Based on the extraordinary scale involved in the implementation of California's MLPA and establishment of its MPA network, it seems unlikely that surf breaks, though colorful in the public eye, beloved by their users, and recently enshrined within language designating surfing as the official state sport of California, will garner a similar level of interest and investment for protection any time soon. However, we hope that this article will stimulate conversation about not only the importance of and potential for surfing resource protection, but, more broadly, to highlight the potential benefits of pursuing a networked, data-supported approach to planning such protections for recreational resources and cultural ecosystem services; and if the MLPA process is any guide, public engagement and participation are critical to such an approach. Climate change and human efforts to adapt and otherwise respond to its impacts present many existential threats for coasts and surf breaks; this is likewise true for many cultural ecosystem services, including other non-surfing recreational resources. As efforts to protect these — and surfing resources — expand, networked protections promise better consideration of key factors for ensuring continued use and equitable access to them.

ACKNOWLEDGEMENTS

The authors are grateful for creative conversations among their colleagues that led to the conception of this manuscript and the thoughtful input provided by the reviewers and editors that led to its improvement.

DISCLOSURE STATEMENT

The authors report there are no competing interests to declare.

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