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Effects of Night Lighting from Proposed Beach Chalet Athletic Fields Renovation, San Francisco, California

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1 Introduction

The City of San Francisco (City) proposes to replace existing turf playing fields at the western end of Golden Gate Park with new synthetic turf fields, sports field lighting, benches and seating for spectators, and new parking and path infrastructure. The project also includes renovation of the restroom building. The City prepared a Draft and a Final Environmental Impact Report (DEIR/FEIR) for the project (State Clearinghouse No. 2011022005) and issued a Coastal Development Permit, which has been appealed to the California Coastal Commission.

This report is an analysis of the effects of the proposed project on coastal zone resources, with a focus on impacts to biological resources from night lighting. The expert qualifications of the authors, Travis Longcore, Ph.D. and Catherine Rich, J.D., M.A., are outlined below (Section 6). Both authors have particular experience in the ecological effects of artificial night lighting (Longcore and Rich 2004; Rich and Longcore 2006; Longcore et al. 2008; Longcore 2010; Rodrigues et al. 2011; Longcore et al. 2012, 2013) and in the ecology and natural history of the natural communities of California.

The project proposal and analysis set forth in the EIR does not adequately describe the extent of light pollution that would occur from the new sports field lighting, nor does it take into account the exacerbating effects of the unique weather conditions on the western side of San Francisco and the project site's location 450 feet from the beach. It improperly discounts the potential impacts to biological resources including nesting birds in the park, migratory birds, seabirds, shorebirds, bats, and any other species currently living in the vicinity of the sports fields. The EIR for the proposed project is far too optimistic that mitigation measures such as lamp design will limit any adverse impacts, especially since the EIR for the project fails to exhibit knowledge of the basic physical properties of light or the different ways in which light affects animal species, including humans. In short, and as elaborated below, the proposed project would create a luminous dome of bright white light where it is currently darker than the surrounding city. This dome, especially under foggy conditions (which occur at least one third of the year), would be the defining visual feature of the nighttime environment in the National Park to the west, and would increase ambient illumination over a wide area to levels that are ecologically disruptive.

2 No Matter How Shielded, Sports Field Lights Cause Light Pollution

The proposed project will cause significant light pollution, despite the use of fully shielded fixtures or compliance with Illuminating Engineering Society of North America (IESNA) or International Dark-Sky Association guidelines. These guidelines do not address impacts to biological systems or sensitive resources and cannot be relied upon to eliminate impacts in parks or other sensitive areas.

The discussion of light pollution that follows repeats many observations already made in the environmental review process by well-respected Dutch lighting expert Henk Spoelstra (see attached). Despite being provided with these comments, the City of San Francisco has not remedied the many errors in methodology and conclusions identified by Mr. Spoelstra.

The proposed lighting system consists of ten 60-foot light standards, each with ten 1,500-Watt metal halide lamps (DEIR, p. ES-1). Therefore, the sports fields will be illuminated by one hundred 1,500-Watt lamps, which the manufacturer claims will produce 134,000 lumens each. The total amount of light will be 13.4 million lumens over 9.4 acres (excluding parking and walkway lighting). As a comparison, a 60-Watt incandescent bulb produces about 800 lumens, which means that the new sports field lighting will be as bright as 16,750 60-Watt incandescent bulbs.

The main argument in the project proposal and environmental assessment is that all of that light will be directed downward and consequently will not affect the surroundings. The EIR neglects, however, to properly account for scattering and reflection of light.

2.1 Reflectivity of turf

The angle that light shines on a surface affects the amount of light that is reflected by that surface. Research on the reflectivity of artificial turf within the visual spectrum of light (390–700 nm) is not readily available, so for the purpose of analysis, we assume that artificial turf has similar properties and is at least as reflective as natural turf. When light shines straight down on turf, roughly 55% of the light is reflected back upward. When the light is at a 60º angle, as little as 12% of the light is reflected upward. The average amount of light reflected upward from light shining on turf at angles of 60–90º is 20–25% (from figures produced by Dr. C. Baddiley, scientific advisor to the British Astronomical Association Campaign for Dark Skies). The light standards for the proposed project are no more than 240 feet from each other and are 60 feet tall, so all of the light will be shining on the turf at angles of 60–90º. Therefore, the proposed project would result in at least 2.7–3.4 million lumens of light reflected up into the sky across the 9.4-acre site from reflection, in addition to the light reflected onto the trees surrounding the site.

2.2 Light scattering by aerosols

Light is scattered by aerosols in the air. These can be dust, pollen, or droplets of water. The EIR fails to account for the scattering of light from fog and clouds or other aerosols that will take place in the 60 feet between the lamps and the ground, or the exacerbating effect of fog and clouds on the light that is reflected from the turf itself.

Anyone who knows the climate of San Francisco is aware of a line that roughly demarcates the foggy western half of the city from the less foggy eastern half. San Francisco as a whole has over 100 days of fog per year, while the western portion, especially the project site, will have more than 100 foggy nights per year (http://www.currentresults.com/Weather/US/cloud-fog-city-annual.php). Fog is extremely efficient at reflecting light and recent research has shown that foggy conditions result in a sixfold increase in night sky brightness (a measure of light pollution) (Ściężor et al. 2012). Furthermore, clouds reflect light downward, so even if it were only cloudy (and not also foggy), the light reflected downward would be substantially greater than that under a clear sky (Kyba et al. 2011; Ściężor et al. 2012). The environmental documentation for the project does not account for either scattering of light by fog or reflection by clouds.

2.3 Light scattering by air

An assessment of light pollution from the proposed sports field lighting should also consider scattering from molecules in the air, which is known as Rayleigh scattering. This type of scattering increases with shorter wavelengths of light, so the light from proposed full-spectrum lamps will be scattered much more than that from the streetlights along the Great Highway. This is because the streetlights along the Great Highway use high-pressure sodium lamps, which have very little light in the shorter wavelengths of the spectrum, while the proposed sports field project would use metal halide lamps, which produce significantly more light in the shorter wavelengths of the spectrum. It is for this reason that full-spectrum lamps (such as metal halide and LEDs) will cause 10–20% more light pollution than high-pressure sodium lamps of the same luminous output (Bierman 2012).

2.4 Comparison with surrounding area

The proposed sports field lighting would be an order of magnitude brighter than the existing lighting on the nearby Great Highway and beach. One of the arguments offered by the project proponents is that the beach area is already lighted and therefore the additional lights to be installed at the sports fields will have little effect. We counted the number of streetlights on the Great Highway along the edge of Golden Gate Park (including those in the parking lot at the beach), the total of which numbered 51. Conservatively assuming that these high-pressure sodium lamps are, at most, 400-Watts each, the total luminous output along the whole edge of the park would be at most 2.3 million lumens. For the stretch of the Great Highway directly corresponding to the area of the sports fields, there currently are only 18 lights, which produce no more than 810,000 lumens. The sports fields would produce 16.5 times the light along the Great Highway in the same part of the park and six times that along the entire width of Golden Gate Park on the western edge.

As for light reflected up from these two sources, the reflectivity of asphalt is generally lower than that of grass, but for light shining straight downward, the percent reflected does not differ by much. Assuming 20% reflectivity for both asphalt and the sports fields, the light reflected upward from the sports fields would be, as calculated above, 2.7 million lumens, while the streetlights would cause 460,000 lumens of reflected light (Figure 1).

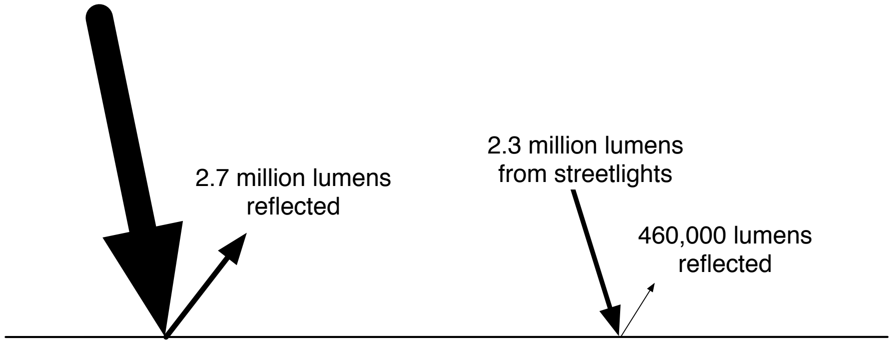

Figure 1. Comparison of total amount of light from proposed sports field project and streetlights along the Great Highway and the amount reflected in clear conditions. Widths of arrows are proportional to total amount of light, and reflectivity is assumed to be 20% reflectivity for both the sports fields and the Great Highway.

In conclusion, the total amount of light produced at the western end of Golden Gate Park will be increased from under 2.3 million lumens (existing streetlights) to 15.7 million lumens. This is a significant adverse impact on the coastal zone. The light reflected ***upward*** from the grass of the sports fields (2.7–3.4 million lumens) will be greater than the total ***downward*** output of all of the streetlights along the western side of the park between Fulton Street and Lincoln Way and will be 3–4 times greater than the output of streetlights between the fields and the beach. During foggy or cloudy conditions, the reflected light from the sports fields will appear dramatically brighter than the existing streetlights, contrary to the claims in the EIR (Kyba et al. 2011).

2.5 Erroneous claims in the EIR about light pollution

The sheer quantity of light proposed at the sports fields belies the conclusions reached in the EIR, which makes some rather incredible claims that are demonstrably inaccurate. Several of these inaccurate and misleading claims are presented and discussed in this section.

Claim: *Thus, the impact of additional artificial lighting on light spillover can depend on such things as the reflectivity and wetness of the synthetic turf, fog conditions, and the phase of the moon. However, even under conservative conditions, the spillover of the lighting would not be expected to travel so far as to adversely and substantially affect the closest neighborhoods, which are located approximately 800 feet from the project site* (EIR, p. IV-B-36).

The claim that the light would not travel to affect nearby neighborhoods is patently false. The calculations provided to support this claim were provided by Musco Lighting. These calculations do not take into account the reflection of light from the turf and other surfaces at the site, nor do they account for the scattering of light in the atmosphere by fog and other aerosols. The renderings in the aesthetics section of the EIR represent dusk in clear conditions and do not accurately depict the impact this project will have on the surrounding area (see comments from H. Spoelstra). As calculated above, the light reflected upward and outward from the sports fields would be approximately 1.2 times the *total* light output of the streetlights between the fields and the beach. The Great Highway is visible from space (Figure 2), and the new lights would make the sports fields immediately inland to it visible as well, appearing as a swath of green much brighter than the lights of the Great Highway, filling in a currently dark part of the park.

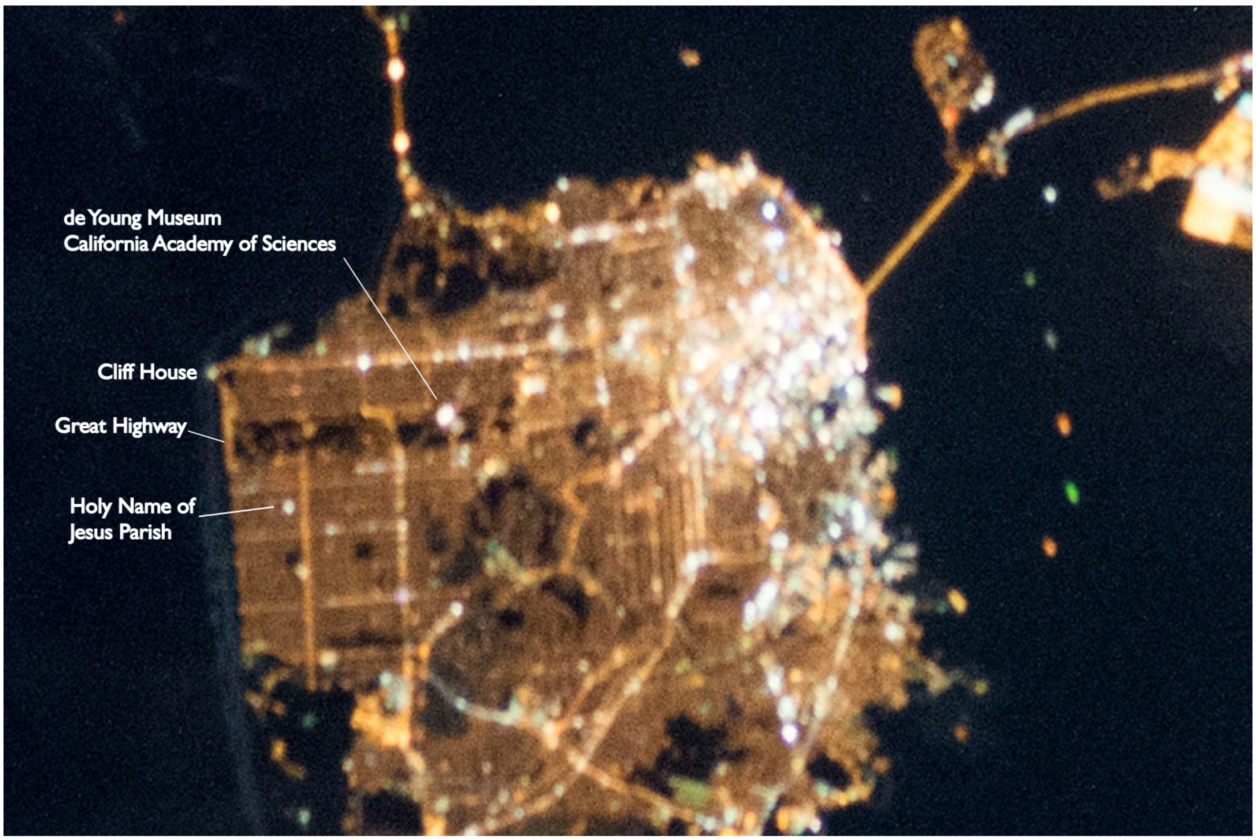

Figure 2. View of San Francisco at night from the International Space Station (ISS034-E-035542, taken January 28, 2013). The overall orange hue is from the use of high-pressure sodium lamps, while the full spectrum bright white of the Holy Name of Jesus Parish lights contrast significantly with the surrounding. When illuminated, the sports fields would be visible from space to the naked eye as a bright green patch.

Claim: *Also, the spillover would not affect the amount of light of the night sky, as the sky appears similar above the athletic field lights as above other areas with no athletic field lights* (EIR, p. IV-B-34).

For this claim to be true, the laws of physics would have to be rewritten. The preparers of the

EIR do not appear to understand the ways in which light is reflected off surfaces or scattered in the atmosphere. Sports fields are the second biggest contributor to light pollution in cities, after commercial districts, and contribute far more to light pollution relative to their area than any other feature (Luginbuhl et al. 2009), except for lights shining directly upward like Holy Name of Jesus Parish in the Sunset District (see Figure 2). It would not be physically possible for the night sky to appear the same above the sports fields with the addition of 2.7–3.4 million lumens of light reflected upward, to say nothing of the even greater night sky brightness that would occur when it is cloudy (four times brighter than clear conditions) or foggy (six times brighter than clear conditions) (Ściężor et al. 2012).

Claim: *A lighting study prepared for the proposed project by Musco Lighting illustrates that within a very short distance of the project site's boundaries (approximately 150 feet), light measurements at heights of approximately 60, 70, 80, 90, and 100 feet above ground level would drop to zero, due to the shielding and focusing of the lights* (EIR, IV.B-36).

These figures were prepared from the perspective of a lighting designer and measure only the direct illumination from the fixtures in question. They do not incorporate light scattering or reflection, which, as discussed above, can be significant. Furthermore, the figures are prepared in footcandles with a resolution of 0.1 footcandles. This information is inadequate because many animals respond to far lower illumination levels than the 0.1 footcandles provided in the maps. Light from a full moon is 0.03 footcandles. Therefore locations identified as 0.1 footcandles on the applicant's lighting plan would be subjected to illumination more than three times greater than that of a full moon, and that does not even take into account scattering and reflection of light. Because many species exhibit lunar cycles in behavior, the illuminations of the full moon, half moon, and new moon are biologically relevant. Experimental studies have shown animal behavior linked to illumination levels orders of magnitude below 0.1 footcandles. Several examples of groups of organisms likely to be found near the project site are discussed below (Section 3 below).

Furthermore, the figures produced by Musco Lighting do not include the illumination that would result from the 47 pedestrian lights or the 13 parking lot lights included as part of the project. The supporting documentation does not include photometric graphs for the fixtures being proposed, either for the sports field lights or for the parking lot and pathway lights, hampering any outside analysis of the design.

A proper analysis of the impacts of the sports field lighting would include legitimate depictions of the conditions during fog, low cloud cover, and clear sky conditions. As provided, only clear sky conditions are analyzed, which simply does not describe the existing climatic norms at the project site.

Claim: ***Light Spillover*** *- Lighting that extends beyond the targeted area* (EIR, p. X.H-60).

This definition, introduced in the FEIR, reveals remarkable ignorance of lighting issues on the part of the preparers of the EIR. The definition is so vague as to be useless. Light is measured in two different ways, which the definition wrongly conflates into "lighting." Light can be measured as *illumination*, which is the number of photons incident on a unit area, or as *luminance*, which is a measurement of the amount of light emitted from a particular area. In lay terms, illumination is what allows you to read a newspaper, while luminance is how bright a light appears when you look at it. It seems that the preparers of the EIR are referring only to illumination in their definition of light spillover, because the lighting diagrams provided only measure illumination. However, many species, especially migratory birds and seabirds, are attracted, to their detriment, to the glare of lights that is measured by luminance. Even though the lights of the sports fields may be shielded, the reflection from the fields themselves will produce glare because of the incredible brightness of the lights shining on them. These lights can affect animal behavior and orientation, especially in foggy or overcast weather conditions.

3 Biological Effects of Light Pollution

Illumination is important to understand because it has biological effects. Small mammals respond to illumination in their foraging activities. For example, artificial light of 0.3 and 0.1 lux reduced the activity, movement, or food consumption of a cross-section of rodent species (Clarke 1983; Brillhart and Kaufman 1991; Vasquez 1994; Falkenberg and Clarke 1998; Kramer and Birney 2001). This phenomenon also has been shown in natural (in addition to laboratory) conditions (Kotler 1984). One lux is roughly 0.1 footcandles, so the amounts of light in these studies were ten times smaller than the resolution of the illumination diagrams in the EIR.

Birds can be extremely sensitive to illumination, and extended foraging by species under artificial lights is documented in the literature (Goertz et al. 1980; Sick and Teixeira 1981; Frey 1993; Rohweder and Baverstock 1996). Many species of shorebirds and other waterfowl have been recorded foraging or roosting under artificial lights (Hill 1990; Thibault and McNeil 1994; McNeil and Rompré 1995). Effects of increased illumination on bird behavior also include changes in singing times (Derrickson 1988; Miller 2006; Kempenaers et al. 2010; Longcore 2010). Those birds that sing earliest are responding to increases in illumination so faint that they are undetectable by humans (Thomas et al. 2002), and well below the resolution of the illumination diagrams in the EIR, which ignore reflected and scattered light. Research has not yet been published on the energetic costs of singing in the middle of the night, but it is likely not to be beneficial to the individual.

Luminance, and the visibility of lights themselves (whether or not they increase *illuminance*, the measure of illumination) also affects wildlife species. Even if illumination is not appreciably increased, merely seeing the light from the project can influence animal behavior.

One example where luminance probably is as or more important than illumination is that of breeding bird density and lights. The one experimental study of the effect of streetlights on breeding bird density shows a negative impact from lights much dimmer than those proposed for the sports fields (De Molenaar et al. 2006). The streetlights in De Molnenaar et al.'s study created a maximum illumination of 20 lux (1.8 footcandles). The adverse effects of these lights (decreased density of black-tailed godwit nests) were experienced up to 300 m (984 ft) from these lights, extending into areas with negligible increased illumination, which means that the adverse impact results from the light being visible, rather than the amount of light incident on the sensitive receptor.

Luminance also presumably is the mechanism that attracts birds and insects to lights. Many families of insects are attracted to lights, including moths, lacewings, beetles, bugs, caddisflies, crane flies, midges, hoverflies, wasps, and bush crickets (Sustek 1999; Kolligs 2000; Eisenbeis 2006; Frank 2006). The metal halide lamps proposed to be installed would generate significant emissions in the ultraviolet (UV) spectrum, which would make them very attractive to insects (Eisenbeis 2006; Frank 2006; Eisenbeis and Eick 2011; van Langevelde et al. 2011; Barghini and de Medeiros 2012). Insects attracted to lights are subject to increased predation from a variety of predators, including bats, birds, skunks, toads, and spiders (Blake et al. 1994; Frank 2006).

3.1 Sensitive bird species found within area could be adversely affected by lights

The FEIR does not adequately describe the presence of sensitive bird species that might be affected by the proposed project. The project proponents could have taken advantage of citizen science efforts that document species. In particular, the Cornell Lab of Ornithology maintains a website called eBird where volunteer citizen scientists enter sightings of birds. There are multiple checks on the accuracy of the data and the resulting database is of sufficient quality to support scientific publication of the results (Fitzpatrick et al. 2002; Sullivan et al. 2009). These data have been relied upon in top international scientific journals (e.g., Wood et al. 2011) and the eBird approach is recommended for scientific inquiry into environmental impacts on birds (Loss et al. 2012). These data certainly meet the standards for scientific information in the environmental review process and provide a significant and sometimes contradictory supplement to the effort undertaken by project biologists in the EIR.

3.1.1 Western Snowy Plover

The EIR claims that Western Snowy Plover is absent because of a lack of habitat. Western Snowy Plover does, however, winter along the beach close to the project site and certainly within the range of influence of the proposed lights. A cursory review of eBird data reveals the presence of Western Snowy Plover quite close to the project site. Given that the species is listed under the Endangered Species Act, the project does not have to impact nesting habitat for protections to be required. Rather, any disruption of Western Snowy Plovers habitat of any kind, or the possibility of disruption of the birds themselves, should have triggered consultation with the U.S. Fish and Wildlife Service. The proposed project would significantly increase the ambient illumination on the beach that is used by this threatened species, which could have adverse impacts by increasing predation. The advantages given to predators by additional light have been well documented (Gotthard 2000; Longcore and Rich 2004). While it may seem a benefit for diurnal species to be able to forage longer under artificial lights, any gains from increased activity time can be offset by increased predation risk.

The FEIR claims the following:

> The EIR was correct in its determination in Table IV.F-2 that snowy plover are absent from the project site and not exposed to project impacts; the species is most commonly found in and near coastal dune habitat and the protection area is over 400 feet distant from the project site at its closest and separated from the

> project area by a major, well lit roadway as well as a fence and a band of generally dense vegetation averaging 200 feet wide (EIR, p. X.L-12).

This argument is not compelling, because the zone of influence of lighting from the proposed project is so much greater than that acknowledged in the EIR. The "well lit roadway" only represents a fraction of the light that will be reflected and scattered from the proposed project, which would produce light in the sky that would be reflected onto plover habitat. Furthermore, the location of the eBird reports for Western Snowy Plovers suggest that the birds are observed over a greater area than indicated in the EIR (Figure 3).

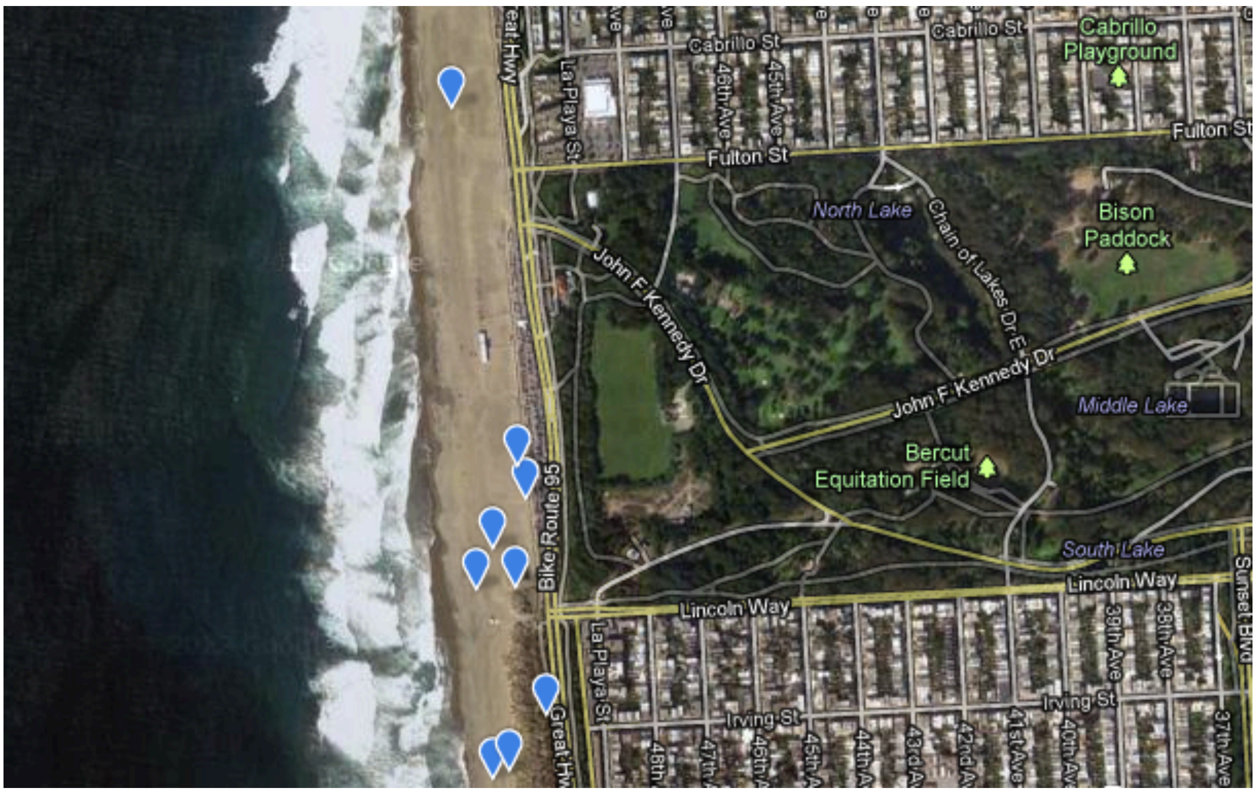

Figure 3. Reported locations of sightings of Western Snowy Plover in vicinity of proposed project (eBird.org). Each blue marker indicates the location of a checklist submitted by a birder who reported Western Snowy Plover.

The EIR fails to analyze what the additional illumination at the beach from the sports fields would do to predation risk for Western Snowy Plovers. As illustrated above, because of reflection of light in the atmosphere, the beach would experience increased illumination when the lights are on at the sports fields. Many species of shorebirds and other waterfowl, including species of plovers, have been recorded foraging or roosting under artificial light (Hill 1990; Thibault and McNeil 1994; McNeil and Rompré 1995). Although plovers forage visually (Evans 1987) and may forage additionally under illuminated conditions, those same conditions increase visibility for predators (Longcore and Rich 2004; Rich and Longcore 2006).

3.1.2 Sensitive raptor species found in project area

The EIR ranks likelihood of presence of Cooper's Hawk as "moderate," yet eBird records show that Cooper's Hawk is present at the project site. It is documented twice in 2012 at the fields themselves (Figure 4). The EIR also ranks likelihood of presence of Red-tailed Hawk as "moderate," when this species is also present at the project site (Figure 5), as is Red-shouldered Hawk (Figure 6).

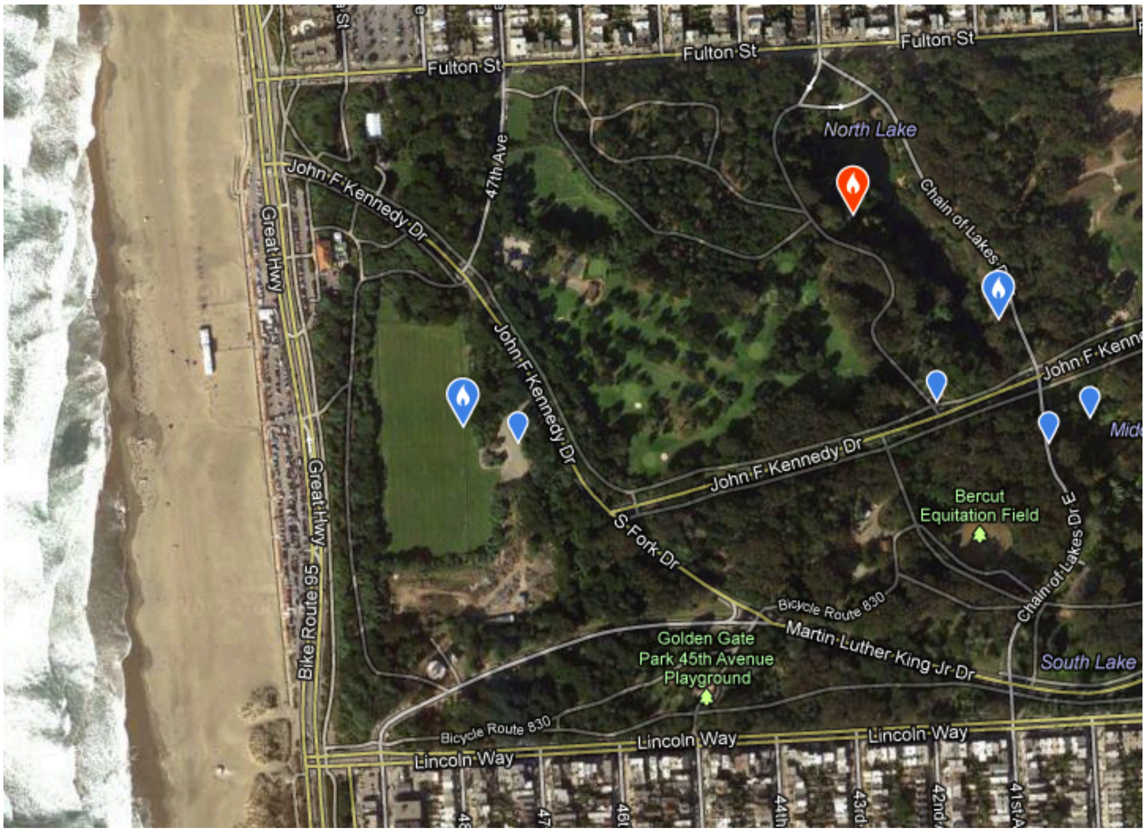

Figure 4. Reported locations of sightings of Cooper's Hawk in vicinity of proposed project (eBird.org). Each small blue marker indicates the location of a checklist submitted by a birder who reported Cooper's Hawk. Blue markers with flames in them represent checklists from locations known as "birding hotspots" where birders reported Cooper's Hawk. Red markers denote checklists from the last 30 days.

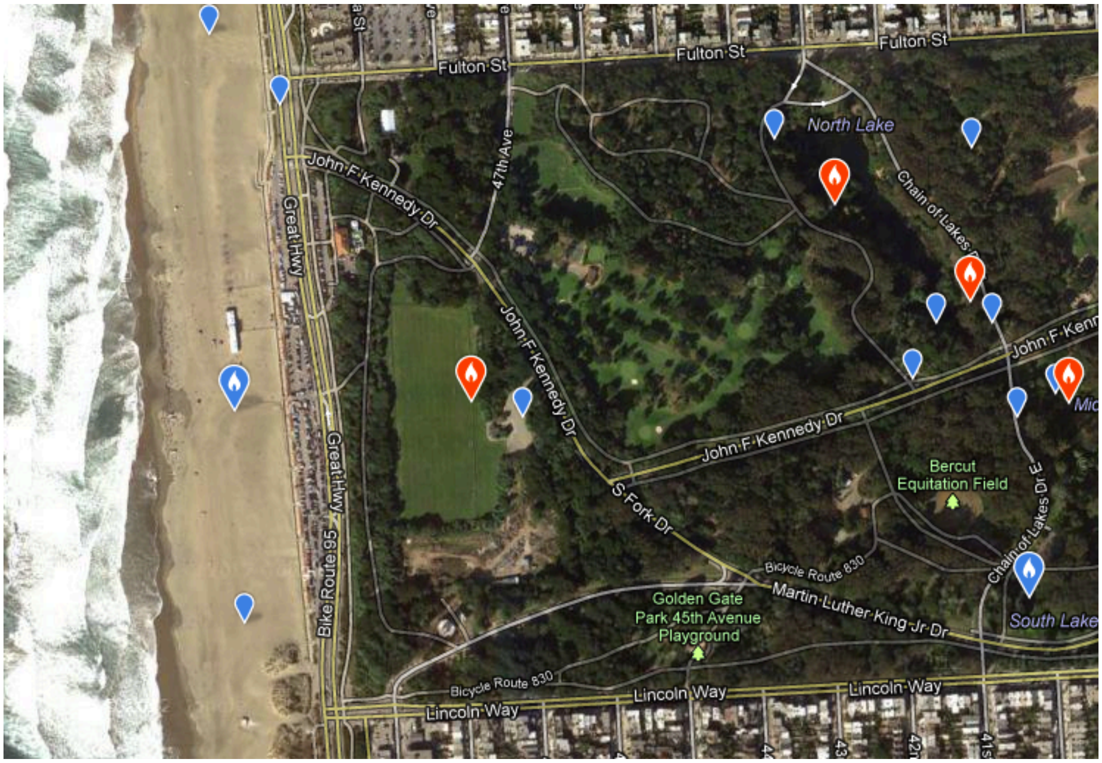

Figure 5. Reported locations of sightings of Red-tailed Hawk in vicinity of proposed project (eBird.org). See above for explanation of symbols.

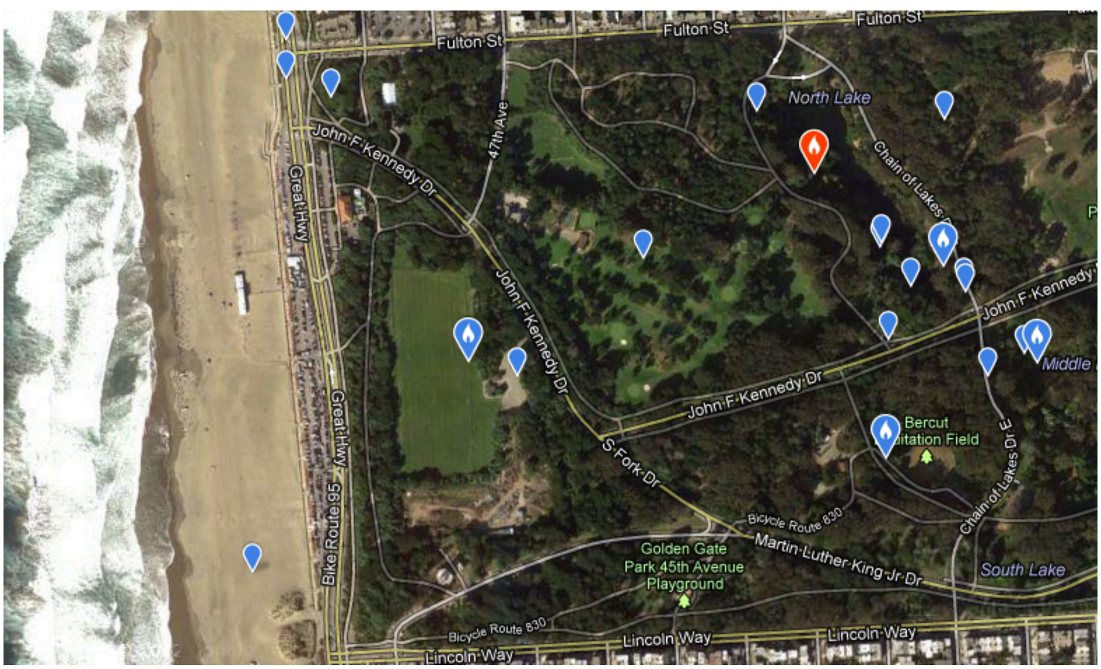

Figure 6. Reported locations of sightings of Red-shouldered Hawk in vicinity of proposed project (eBird.org). See above for explanation of symbols.

The FEIR acknowledges that more sensitive bird species are present in the project area than assumed in the DEIR, but uniformly asserts that the project will have no impact upon them, despite loss of foraging area and disruption of the nocturnal environment. Yet, the EIR fails to engage any of the relevant literature on disruption of bird reproductive cycles by lights (Rowan 1938; Havlin 1964; Lack 1965; Rees 1982; De Molenaar et al. 2006; Kempenaers et al. 2010) and consequently lacks any evidentiary basis to conclude that these sensitive species will not be affected.

3.1.3 Attraction of migratory birds

The EIR claims that the sports fields will not be an attractant to migratory birds, arguing as follows:

> Given the typical altitude at which migrating birds fly, the fact that the proposed athletic field lights would be shielded, and studies that suggest night-flying birds are attracted to point-sources of light, rather than larger illuminated areas, it is unlikely that the lighting associated with the proposed project would interfere with a migratory corridor or provide a hazard for migratory birds through the phenomenon of light "entrapment" (EIR, p. IV.F-28).

So many things are wrong with this statement that it is hard to decide where to start. Having written and edited several scientific papers and book chapters on bird attraction to and mortality at lighted structures, we are quite familiar with this literature (Gauthreaux and Belser 2006; Longcore et al. 2008; Longcore et al. 2012, 2013).

First, one cannot assess the impacts of lights based on the "typical altitude" at which bird fly. It is well known, and has been well known for decades, that light attraction and associated adverse impacts occur when the cloud ceiling is low (e.g., a storm front is coming through) and birds are forced to a lower altitude (Gauthreaux and Belser 2006; Longcore et al. 2008; Longcore et al. 2012). This argument is completely without merit or basis.

Second, the preparers of the EIR suggest that because the lights would be shielded, there would be no light to attract the birds. This is wrong, because it ignores that light can be reflected and, especially importantly for this project, scattered by fog and reflected by low clouds. In fact, one of the higher mortality events at a wind turbine installation occurred at a location with lights that were at ground level and created a light attraction in conjunction with fog (Kerlinger et al. 2010; Kerlinger et al. 2011). Given that the project site will be foggy half of the year, that the lights would be shielded does not eliminate risk, and even when it is not foggy, the reflected light is more than adequate to attract migratory birds (Lebbin et al. 2007).

The EIR suggests that birds are attracted to "point-sources of light" and not to illuminated areas, when this conclusion is not supported by the literature. One study on juvenile seabirds heading to the ocean from their Hawaiian island nest sites found that attraction was reduced by eliminating the point sources of light (Reed et al. 1985), but this conclusion has not been generalized. In fact, Lebbin et al. (2007) documented an interspecific flock of migratory songbirds that gathered under stadium lighting consisting of 156 1500-Watt metal halide lights illuminating a stadium at a university. Nothing about the design of the lights at Golden Gate

Park would make them any less attractive to migratory birds than the lights in the study. To assert otherwise is wishful thinking on the part of the preparers of the EIR.

The conclusion that the lighted fields would not be an attractive hazard for migratory birds is therefore not based on the best available science and the EIR preparers make unsubstantiated assertions that seem intended to downplay the impacts of the proposed project rather than to identify and avoid those impacts.

3.1.4 Attraction of seabirds

Seabirds are particularly attracted to lights at night (Murphy 1936, Reed et al. 1985), presumably because they cue in on bioluminescent organisms while foraging (Montevecchi 2006). In coastal regions, seabirds such as storm-petrels are routinely observed at athletic stadia, having been attracted to the lights (Montevecchi 2006), including Leach's Storm-Petrel around the lights of Candlestick Park in San Francisco (B. Sydeman pers. comm., in Montevecchi 2006), and Ashy Storm-Petrel at Stanford Stadium in October 2011 (http://groups.yahoo.com/group/south-bay-birds/message/6849). Given that the proposed project is closer to the open ocean than these two sites, it can be expected to attract seabirds, especially during overcast and foggy conditions, when these species fly closer to the shore (Montevecchi 2006). This is of particular concern along the California coast because of the documented high level of attraction to night lights exhibited by the two species of *Synthliboramphus* murrelets, which are of significant conservation concern (Pacific Seabird Group 2002).

3.2 Impacts on bat species not well described

The analysis of impacts to bat species in the project's environmental analysis is muddled at best. The EIR indicates "moderate" potential for two bat species to occur: Yuma myotis (*Myotis yumanensis*) and Western red bat (*Lasiurus blossivilli*). An acoustic survey for bats of San Francisco parks in 2008–2009 documented *Myotis yumanensis* and *Tadarida brasiliensis* in Golden Gate Park (Krauel 2009). Yuma myotis is a California Species of Special Concern and has a foraging range of 2–4 km (Evelyn et al. 2004). Patches of forest with roost sites were 126–416 m (95% CI) from open water in a study from the Bay Area (Evelyn et al. 2004), while the project site is approximately 500 m from North Lake. It therefore follows that the project site is well within the range for foraging by Yuma myotis and potentially even could be host to roost trees, which can be native or exotic as long as they are large (Evelyn et al. 2004).

If ambient illumination were to be increased at a roost site, it would cause adverse effects, and the brightness of the proposed lights ensure that illumination will be increased in the entire area surrounding the project (as discussed above, due to reflection and scattering). One such adverse impact could be a delay in the onset of foraging time resulting from illumination near roosts, which has been shown for several species of bats (Boldogh et al. 2007; Stone et al. 2009).

Studies have furthermore suggested that *Myotis* bats do not forage at streetlights (Furlonger et al. 1987; Rydell 1992), but this may be due in part to not liking to be exposed to light in open habitats, since they will forage on insects attracted to lights set up experimentally in desert scrub (Fenton and Morris 1976; Bell 1980). The existing soccer fields are likely to be a foraging site for this species of bat because they consume all manner of insects, which would be found at and around a grass field that is regularly irrigated. The project would remove this foraging area and probably decrease any foraging at the preferred interface between the field and forest where insects would be most abundant; forest edges are important insect habitats (Fried et al. 2005), and bats are particularly active along edges (Gehrt and Chelsvig 2003).

We can therefore presume a negative impact on this Species of Special Concern. The EIR dismisses the loss of habitat as being "only" 5% of the foraging area in the park. This calculation is unsupportable; it could only be true if the other grassy areas of the park were not heavily used themselves. Such activities include use of the meadows for concerts that attract hundreds of thousands of people yearly and, in the weeks before, during, and after each event, involve heavy equipment, noise, and other activities inconsistent with bat foraging. Therefore, the loss of this area characterized as "only" 5% of the habitat could be considered a significant loss of coastal zone resources.

3.3 Spectrum of lights proposed increases biological impacts

The environmental analysis for the project does not incorporate any of the voluminous research that shows the differential effects of different wavelengths of light on biological systems (see reviews in Rich and Longcore 2006). Neither the aesthetics analysis nor the biological resources analysis takes into account the wavelengths of light that would be produced by the proposed project. This light, as produced by metal halide lamps, would be much "whiter" than existing lights in the vicinity of the project. The color temperature of the lights proposed for the project would be 5000 to 8000 K, which is a very "cold" blue light (EIR, p. X.H-56). By contrast, incandescent bulbs produce much "warmer" light that does not have emissions in the shorter wavelengths (blue, violet, and ultraviolet) that are present in light from metal halide lamps. A high color temperature appears whiter while a low color temperature appears yellower.

The conclusion from a number of studies on humans and wildlife is that whiter light (that is, full-spectrum light with blue and violet light included) has more adverse impacts (Pauley 2004; Rich and Longcore 2006; van Langevelde et al. 2011; Gaston et al. 2012; Stone et al. 2012).

The blue-heavy spectral character of the metal halide lamps has the potential to affect human health because blue light gives a physiological signal to humans (and other organisms) that it is daytime, disrupting circadian rhythms (Pauley 2004). The wavelengths of light that we see as blue are 500 nanometers (nm) and shorter. Light of these wavelengths, when sufficiently bright, suppresses the production of the hormone melatonin in humans and other animals. This can occur at levels previously thought to be too dim to have any effect (< 1 lux, while a streetlight illuminates to 15–100 lux) (Brainard et al. 2001). Melatonin is naturally produced at night as humans sleep and provides many health benefits, including playing a role in preventing breast and prostate cancer (Davis et al. 2001). Scientists have shown that regions of the world with high levels of outdoor lighting have higher breast and prostate cancer rates. For example, studies have shown:

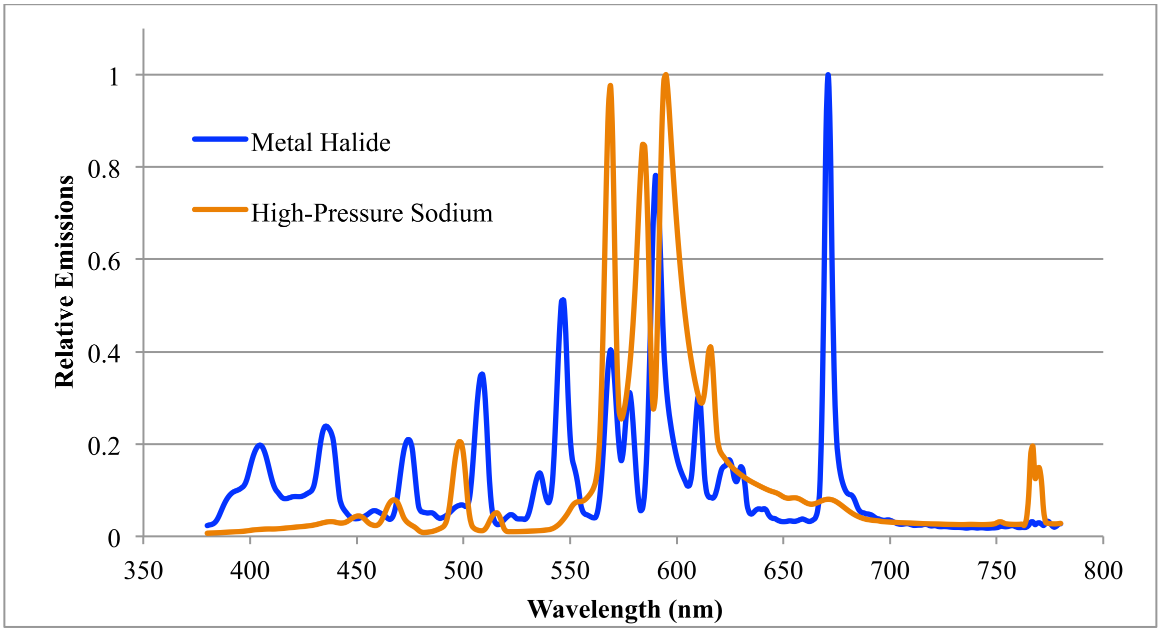

Figure 7. Comparison of emissions from metal halide lamps (proposed sports fields) and high-pressure sodium lamps (existing streetlights). Estimated with available spectral curves for 100-Watt metal halide and 150-Watt high-pressure sodium lamps (Elvidge et al. 2010). The metal halide lamps have significantly more emissions in the blue, violet, and ultraviolet (< 495 nm) and consequently cause greater sky glow and have greater potential influence on circadian rhythms (which peak at 460–490 nm) (Pauley 2004).

- Breast cancer tumors that are grafted onto rats grow much faster when nourished by blood from women exposed to light at night (i.e., low melatonin) than do tumors nourished by blood taken from women who were in darkness before the blood draw (i.e., high melatonin) (Blask et al. 2005).
- Women who report having more light in their bedrooms are at significantly greater risk of breast cancer than women who report that their bedrooms are dark (Kloog et al. 2011).
- Globally, breast cancer risk in countries with the brightest outdoor lighting is 30–50% greater than countries with the lowest outdoor lighting, even when accounting for other demographic differences (Kloog et al. 2010).
- Within a country (Israel), the level of outdoor lighting was significantly associated with breast cancer risk after all other demographic and ethnic variables were controlled (Kloog et al. 2008).
- Risk of prostate cancer was found to be significantly greater for men living in areas of the world that have the most outdoor lighting, when all other factors were controlled (Kloog et al. 2009).

Exposure to light at night and associated sleep disruptions, which can be caused by bright streetlights outside houses and apartments, is also associated with depression, insomnia, mood disruptions, weight gain, and metabolic disruption (Chepesiuk 2009; Fonken and Nelson 2011).

3.4 Beach and shoreline ecology is vulnerable to light pollution

The inland end of the beach of the Pacific Ocean is only about 450 feet from the proposed lights. Even though human visitors heavily use this beach, it is also an important habitat for other species, and is especially used at times when human use is lower (e.g., at night).

As a general rule, additional light, whether moonlight or artificial light, increases foraging efficiency of predators and reduces activity of prey (Longcore and Rich 2004; Rich and Longcore 2006; Seligmann et al. 2007). This phenomenon has been shown many times in different habitats, including beaches (Bird et al. 2004). For example, ghost crabs are active only at night, and avoid activity under both the full moon (Schlacher et al. 2007) and artificial light (Christoffers III 1986).

Effects from lights near shorelines may also affect aquatic ecosystems. For example, the predator-prey dynamics of fish and marine mammals are affected by lights (Hobson 1965; Hobson et al. 1981; Yurk and Trites 2000; Nightingale et al. 2006). In general, additional light provides benefits for predators, except when their prey are schooling species, in which case the predator defense mechanism of a school is enhanced (Nightingale et al. 2006).

Shorebirds sometimes forage at night (Dugan 1981; Burger and Gochfeld 1991; Rohweder and Baverstock 1996), probably as a defense against predation (Robert et al. 1989; McNeil et al. 1992; Thibault and McNeil 1994), and as a result of slightly higher invertebrate activity on beaches at night (Dugan 1981; Evans 1987). Predator defenses of shorebirds are different during the night compared with the day; in an observational study some proportion of Dunlins remain motionless and limit vocalizations as a defense at night while all individuals in a flock fly away in response to predators during the day (Mouritsen 1992). Some shorebirds forage under artificial lights, presumably because they can do so by sight instead of by touch (Dwyer et al. 2013). Time of foraging in shorebirds is therefore likely the result of tradeoffs between the risk of becoming prey with ability to detect their own prey. The proposed project will affect the ambient illumination conditions for shorebirds on the beach at night, which may adversely impact some species (e.g., small species such as Western Snowy Plovers), while extending foraging times for other species. This should be considered an adverse impact since it further disrupts natural patterns and cycles of illumination.

3.5 Curfew on lights does not eliminate impacts

Substantial evidence exists to conclude that even though sports field lights would not be on all night, they still would have a substantial impact on wildlife. The examples use species not present at the park, but illustrate a general ecological principle.

First, many groups of species share resources across lighting levels; that is, one species may forage at dusk, another right after dusk, and another in the dark of night (Hailman 1984). By lighting the fields (and adjacent habitats) the project essentially would eliminate the range of illumination experienced by habitats surrounding the fields. Rather than a smooth range of illumination conditions as the sun goes down and darkness falls, sites will experience a single illumination level until the sports field lights are turned off. For a substantial portion of the evening, this will favor those species that are adapted to the artificial lighting level. As shown in experimental studies on amphibians, the increased illumination levels influence the outcome of competitive interactions. The predicted result of lights, even if switched off at an hour certain, is a reduction in species diversity.

Second, increased illumination, even on a temporary basis, reduces the time available for critical behaviors. The research on frogs illustrates that mating and other reproductive behaviors are highly dependent on lighting levels. If artificial lighting eliminates a significant period of potential breeding time for a species, the long-term consequences will be negative. This is illustrated by the foraging activities of western toad (*Bufo boreas*), which is concentrated at certain illumination levels (Buchanan 2006). If artificial lighting such as that proposed for the sports fields, or even streetlights, were present in the toad's habitat until 11 P.M. each night, any such crepuscular species would be deprived of one-half of its available foraging time, a significant impact by any estimation.

4 Mitigation Measures

The mitigation measures proposed in the EIR for the project will be inadequate to eliminate adverse impacts to coastal zone resources.

Mitigation Measure BI-1 requires preconstruction bat surveys. This only looks for bat roosts, not for bat use of the habitat and consequently the adverse impacts of eliminating bat foraging habitat will remain. No mitigation measure could feasibly protect bat foraging habitat as long as the lights are to be installed and operated as proposed.

Mitigation Measure BI-2 addresses lighting design. The design guidance proposed in this mitigation measure is inadequate to protect existing nighttime conditions and the species that depend on them. Although these modest design guidelines may marginally reduce certain impacts, the proposed project would still introduce a large and bright source of light on the landscape that would be exacerbated by the local climatic conditions.

The environmental review completely ignores the effects of fog on the scatter of light from the project. A possible mitigation might be to turn the lights out automatically under foggy conditions and during bird migration season. These two mitigations were recommended at one point by the Coastal Commission for the floodlights proposed (and subsequently abandoned by the project applicant) for the Vincent Thomas Bridge in 2003 (see application number 5-00-384-A1). Such operational controls would be the minimum mitigation necessary to reduce adverse impacts from the project. Of course, the project would then not achieve its stated goal of providing a certain number of hours of field time.

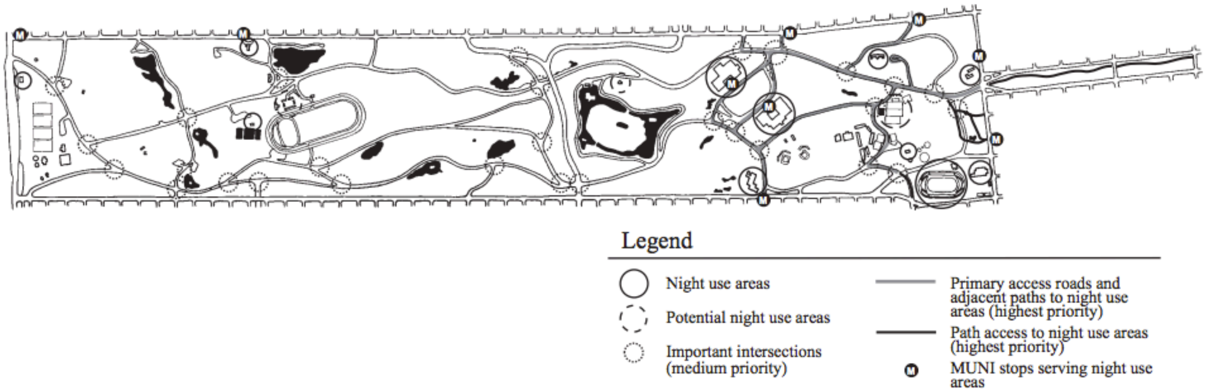

Figure 8. Adopted lighting Master Plan for Golden Gate Park. The sports fields at the western edge of the park are not identified as a location for night use.

5 Conclusion

Based on the analysis above, we conclude that *the project goal of a lighted field cannot be achieved without significant adverse impacts on coastal zone resources*. The Commission should protect those resources, and in this instance, should only approve a renovated grass field and bathroom structure without any of the proposed sports field lighting. Such a recommendation would actually be consistent with the adopted Master Plan for Golden Gate Park, which does not propose any nighttime use at the project site (Figure 8).

6 About the Authors

Dr. Travis Longcore and Catherine Rich are the principals of Land Protection Partners. Dr. Travis Longcore is Associate Professor (Research) at the USC Spatial Sciences Institute and Associate Adjunct Professor at the UCLA Institute of the Environment and Sustainability where he has taught, among other courses, Bioresource Management, Environmental Impact Analysis, Field Ecology, and the Environmental Science Practicum. He was graduated *summa cum laude* from the University of Delaware with an Honors B.A. in Geography, holds an M.A. and a Ph.D. in Geography from UCLA, and is professionally certified as a Senior Ecologist by the Ecological Society of America. Catherine Rich holds an A.B. with honors from the University of California, Berkeley, a J.D. from the UCLA School of Law, and an M.A. in Geography from UCLA. She is Executive Officer of The Urban Wildlands Group and lead editor of *Ecological Consequences of Artificial Night Lighting* (Island Press, 2006) with Dr. Longcore. Longcore and Rich have authored or co-authored over 25 scientific papers in top peer-reviewed journals such as *Conservation Biology*, *Biological Conservation*, *Current Biology*, *Environmental Management*, and *Frontiers in Ecology and the Environment*. Land Protection Partners has provided scientific review of environmental compliance documents and analysis of complex environmental issues for local, regional, and national clients for 15 years.

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