This Little Light of Mine:
More Ecological Consequences of Artificial Light at Night

by Jay Adams

Much of the concern about the negative consequences of artificial light at night has resulted from an increasing understanding of the vast number of birds killed, injured or in other ways, stressed each year during migration from contact with lighted buildings, transmission towers, light ships, off-shore drilling rigs, lighthouses, and other sources of up-shining light. Much of the reaction to these consequences has focused on retrofitting or replacing outdoor luminaires so that their light does not shine up. Many communities, including some on Whidbey, are switching to light-emitting diode (LED) streetlamps as a means of reducing energy costs. The replacement luminaires are configured to shine no light above the horizontal plane of the fixture. This is good news for the birds, but it does not address, and may even increase, the negative ecological consequences of artificial light at night on earth-bound creatures, nocturnal and otherwise, that need the dark in order to live. We humans are on that list.

Here are some of the ways that artificial light at night can negatively affect life forms others than birds:

- Sea turtle hatchlings can lose their way in the presence of artificial light at night (henceforth ALAN) and thus fail to reach the sea.
- Snakes, salamanders and frogs restrict movements on full-moon nights to reduce the chances of predation. ALAN alters this behavior. Every night becomes a full-moon night. Salamanders delay feeding in lighted areas and can even lose their important homing ability.
- Some tree frogs stop producing territorial song in the presence of ALAN. No singing means reduced breeding, as the singing attracts mates. For frogs, the dark-light circadian schedule regulates physiological functions, including production of the hormones that control fat accumulation in preparation for winter hibernation and the timing of egg production.
- Squirrel Tree Frogs forage at lower light levels than do Western Toads. Under ambient light conditions, their forage times do not overlap. ALAN changes this timing, resulting in foraging competition.
- For many fish species, feeding, schooling, and migration depend on specific light intensities. Fish schools may disband and cease feeding in the absence of needed light cues. ALAN can cause temporary blindness in fish, leading to a greater risk of predation.
- Varying underwater light levels are used by fish to partition their otherwise shared feeding grounds. ALAN can destroy the subtle differences on which the fish rely.
- Salmon change their migration behavior and distribution in night-lighted areas. Increasing ALAN raises the chances for salmon, herring, and sandlance mortality. Predators take advantage of lighted spillways, fish ladders, and bridges. Harbor seals congregate under artificial light to consume juvenile salmon. In one experiment, turning the lights off reduced salmon predation to natural, lunar-driven levels.

Artificial light at night (ALAN) is not just a problem for anadromous fish. Light levels in urban lakes and ponds as well as streams, estuaries, and the pelagic zone can equal or exceed full moonlight, altering behaviors and upsetting biological clocks.

Not really fish, but mollusks, California Market Squid have switched from daytime reproduction to nighttime reproduction in the presence of lighted fishing and research vessels. The result has been increased squid mortality.

Insect species are especially sensitive to artificial light because they have no ability to resist light stimulation. They can become fixated, entrapped, or they may crash, all of which reduce populations over time.

Fireflies can lose the ability to see and make use of their flashing signals.

Nocturnal pollinators reduce visits to plants in the presence of artificial light. In one study, this resulted in 13 percent less fruit set even though the plants also received the normal number of visits by daytime pollinators.

Like other insects, moths have many independent photo-receptive circadian pacemakers located in different types of tissue. Sunlight synchronizes them. Synchronization of life cycles with lunar cycles may help moths navigate, mate, oviposit, feed, and avoid predators. By simulating moonlight, ALAN can disturb or alter these behaviors.

It can also rearrange predator and prey relationships. Zooplankton exhibit vertical migration through the water column in response to small changes in light intensity. Organisms residing deep in the water column during the day ascend at dusk to shallower depths where they feed, then return to greater depths at dawn. On moonlit nights, migration is put off. ALAN routinely suppresses zooplankton vertical migration. In artificial light, every night is moonlit.

Stream macro-invertebrates such as Mayfly nymphs and bottom-dwelling crustaceans exhibit stream drift. They live on the bottom, detach, and drift with the current to forage at night. This is not passive but active drifting. It is cued by lowlight conditions.

Mammals are not immune from the effects of artificial light at night. Their physiological, behavioral, reproductive, communications and other effects are at work, too. Coyotes, for example, howl more frequently at the time of the new moon. This allows them to communicate to reduce trespassing by other flocks or to assemble packs to hunt. ALAN disrupts these behaviors.

Some bats have learned to feed at streetlights, so much so that such behav-

ior is now considered part of the normal life habit of many species. This adaptation may reward the bats, but it can have dramatic negative effects on the insects on which bats prey.

ALAN **affects plants as well as animals.** Their photo-receptors govern germination, phototropism, conversion from the vegetative state to the flowering state, flower development, fruit development, and dormancy, and help plants measure day length, light quality, light intensity, light direction, and light duration. In darkness, plants maximize stem growth and elongation. In the light, leaf formation and leaf expansion are maximized. Alter this natural order of things and plants suffer the consequences.

ALAN can also rearrange relationships between members of a living community. Sometimes, ALAN can benefit a member of the group. But that benefit comes at a cost to some other member. Thus, crows have learned to roost in lighted areas, ostensibly to avoid predation by owls. Such behavior is good for the crows, but potentially bad for the owls. Such balances are key to our understanding of the effects of artificial light at night.

An emerging concern related to artificial light at night is not the light itself but the color of the light. This concern is deepening as a result of the colors of light emitted by LED lamps. That color is measured in terms of Kelvins. The higher the K-number, the more the light is made up of shorter blue wavelengths — which make the light look bright white. For humans in particular, these short blue wavelengths can disorient human vision in ways akin to snow blindness. The eyes of older adults in particular often have trouble adjusting to rapid light/dark changes such as those experienced while driving at night in areas lit by streetlights with LED lamps above 3,000K.

But more than temporary loss of visual clarity, artificial light at night, and in particular, short wave-length blue light, can throw off our biological clocks. Humans need darkness at night because darkness stimulates the production of melatonin and other hormones which mediate not only activity patterns but almost every other physiological or behavioral rhythm, including tumor growth. *This is true not only for us and other mammals but for nearly every other life form, too.*

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The significance of this was recently documented in two ways. First, the American Medical Association, at its annual meeting in 2016, adopted an official policy statement about street lighting. Pointing out that LED streetlamps rated above 3,000K have five times the ability to alter circadian sleep rhythms, not to mention their effects on driving safety, the policy recommends not only that communities install luminaires at or below 3,000K, but also that the lights should be *dimmed* during off-peak hours. Second, in October 2017, the Nobel Prize for science was awarded to three physicians for their work to identify the workings of Circadian Rhythm. Specifically, the doctors identified the gene that encodes a protein that accumulates in cells at night, and then is degraded during the day. Their work was done with fruit flies, *but they now realize that biological clocks function by the same principles in the cells of other multi-cellular organisms, including humans.*

"With exquisite precision," according to the prize story on National Public Radio, "our inner clock adapts our physiology to the dramatically different phases of the day and night. The clock regulates critical functions such as behavior, hormone levels, sleep, body temperature and metabolism."

Tamper with those functions and we open ourselves to nervous conditions, language difficulties, analytical challenges, long-term memory impairment, tumor development and growth, diabetes, depression and obesity.

Fortunately, there are steps all of us can take to reduce or eliminate the negative effects of artificial light at night. The most obvious step is to turn off all outdoor lighting that is not absolutely necessary.

Other steps include replacing current fixtures with lamps that not only don't shine up, but that also do not shine out. In other words, choose a fixture that only emits light straight down. In addition, only use bulbs rated at 3,000K or less. A quick internet search will locate such lights in many styles and price-ranges.

In addition, ask Puget Sound Energy to add shields to any streetlights that shine on or at your property. This includes the newer LED lights that are being installed in some communities on Whidbey.

Indoors and out, use only LED bulbs rated 3,000K or lower (2,700K is becoming the standard indoor household rating). Bulbs are now available that mimic the three-way bulbs that once were common, only these bulbs come not in three wattages, but in three K ratings. I have one where I can choose 2,700K, 2,500K or 2,300K depending on the task at hand and the time of day. Twenty-three hundred approaches the orangey firelight look of the older high-pressure sodium streetlamps that can still be seen from place to place. The lower the Kelvin number, the less the light negatively affects our circadian clocks.

Finally, one can also download laptop, tablet and smart-phone apps that lower the K-value of the light emitted by your devices. The apps use your location to identify the times of dusk and dawn and then change the color of the screen to be more circadian-rhythm friendly, according to settings you control.

For more information, please see Catherine Rich and Travis Longcore, editors; ***Ecological Consequences of Artificial Night Lighting.*** Island Press, 2006. An eBook version is available. An internet search on the book title will yield many additional resources, including detailed references to recent medical findings.