DO SEA TURTLES SEE THE LIGHT?

DEVELOPING SOLAR-POWERED ILLUMINATED NETS TO REDUCE SEA TURTLE BYCATCH

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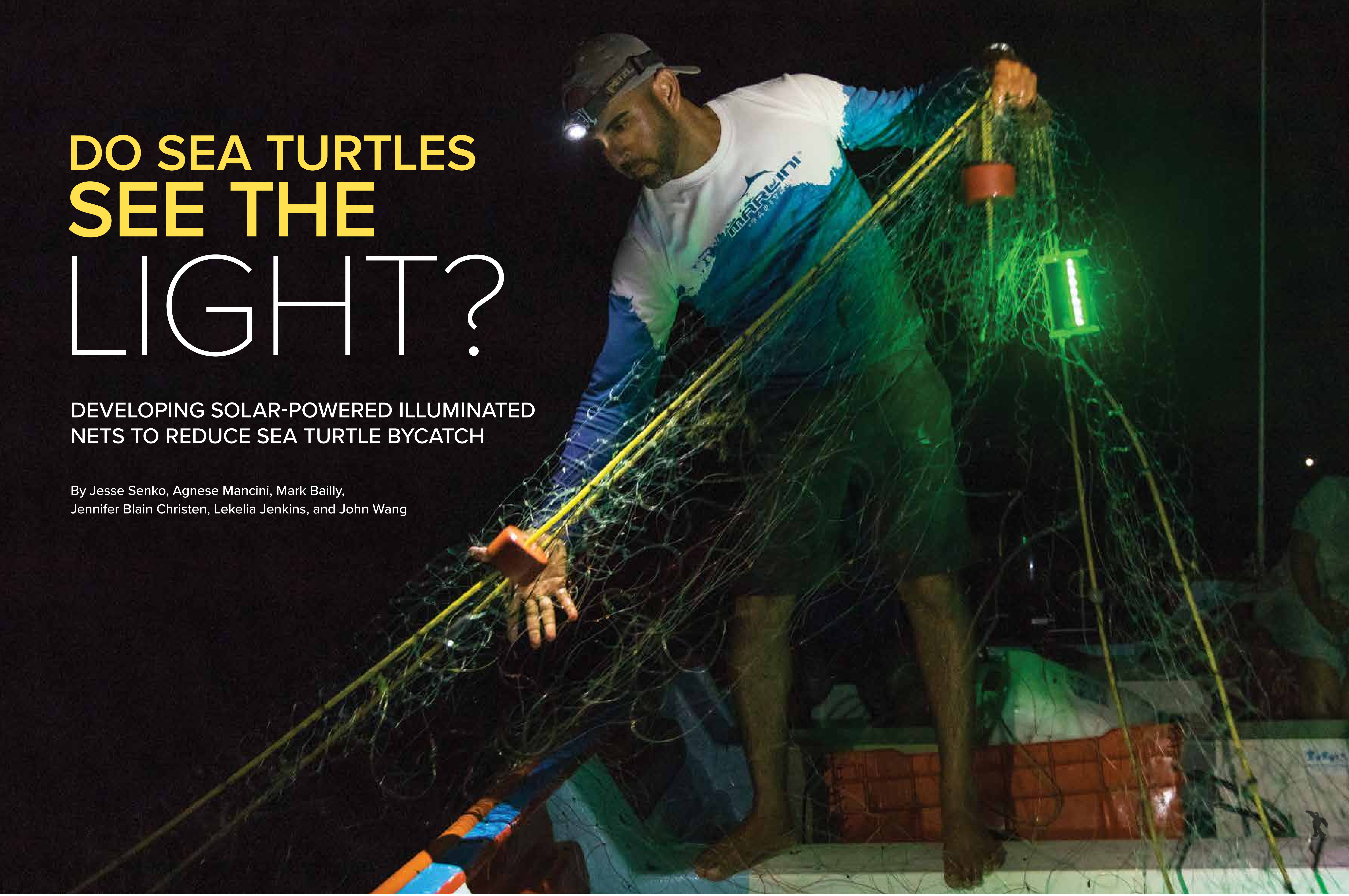


Small-scale or coastal fisheries are vital for food supply, food security, nutrition, income, and livelihoods worldwide. However, both overfishing and incidental catch (bycatch) of nontarget species in coastal fisheries can jeopardize their long-term viability and create problems for threatened species and sensitive habitats, as well as for the coastal communities that depend on those fisheries. Bycatch of sea turtles in gillnet and entangling net fisheries has been linked to declines in sea turtle populations worldwide and has also led to costly closures of fisheries in coastal communities that have few economic alternatives.

Unlike studies of industrial-scale fisheries, limited research has been done to evaluate bycatch and develop technologies that reduce bycatch impacts in coastal fisheries. But that is beginning to change. Recent research has found that net illumination—using battery-powered light-emitting diodes (LEDs) or chemical lightsticks—is capable of reducing bycatch of sea turtles (by 40–74 percent) as well as small cetaceans (by 70 percent) and seabirds (by 85 percent) in coastal net fisheries at night while maintaining catch rates of target fish species. Although the exact reasons why this technology is effective are not yet known, net illumination is believed to provide a visual cue that alerts sea turtles and other nontarget species to the presence of nets or otherwise deters them.

… we are working to make solar-powered net illumination more accessible on a global scale.

Testing of net illumination has expanded into multiple coastal fisheries worldwide, but broader implementation has been hindered by the lack of a sustainable method to illuminate nets that addresses energy demands, as well as a design that matches the specific needs of gillnet fishers. In particular, light levels in LEDs that are currently used begin to diminish after a few weeks of continual use, and the energy demand means that batteries must be changed monthly to maintain their effectiveness in reducing bycatch. This results in high costs for coastal fishers as well as environmental concerns over battery disposal. For example, LEDs used in previous bycatch-reduction research used two AA batteries per LED. One gillnet fishing vessel with 1 kilometer length of net with LEDs spaced every 10 meters would use 100 LEDs, so 200 AA batteries would be needed for every change of batteries. Moreover, previously tested designs of LED lights were not optimized for net fishery operations, causing frequent snags and weighing down the net.

DEVELOPING SOLAR-POWERED NET ILLUMINATION

To address the challenges associated with current net illumination technology, we partnered with coastal fishers to develop a novel way to illuminate nets by harvesting renewable energy. Involving fishers in developing new gear and practices is an important step toward achieving fisher adoption and compliance of bycatch reduction technologies. Indeed, the most widely adopted gear modifications in commercial fisheries were developed by, or with strong input from, local fishers. Thus, in January 2018, we held our first of three workshops with local fishery leaders from northwestern Mexico to discuss developing a renewable-powered solution.

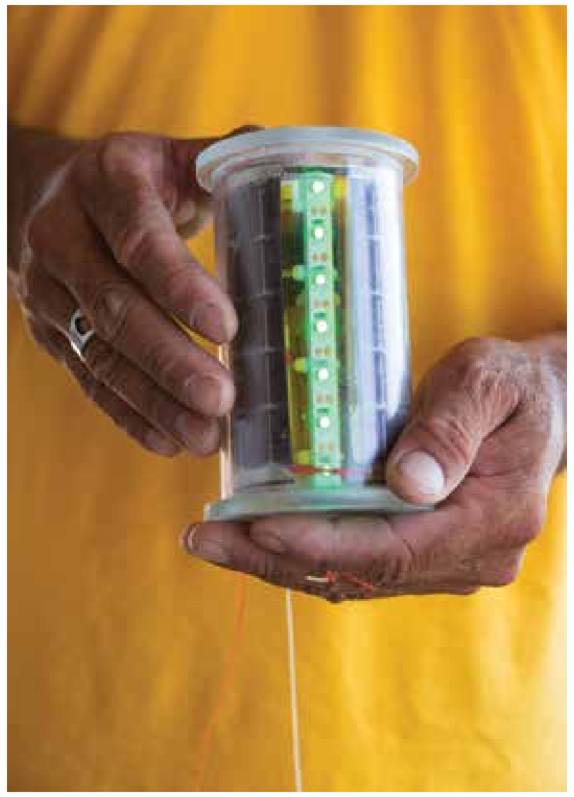
At the beginning, we considered both mechanical and solar energy sources. All of the mechanical energy designs that did not risk failure because of biofouling (for example, turbines) had low power outputs that precluded them from generating a reasonable intensity of light. We therefore chose to use photovoltaics, which have no moving parts, provide high power output compared with other renewable energy sources, and require little human intervention to operate effectively. However, we still needed to design a system that effectively oriented the solar cells, as well as establish a flash rate for the LEDs that would minimize energy consumption while still deterring sea turtles.

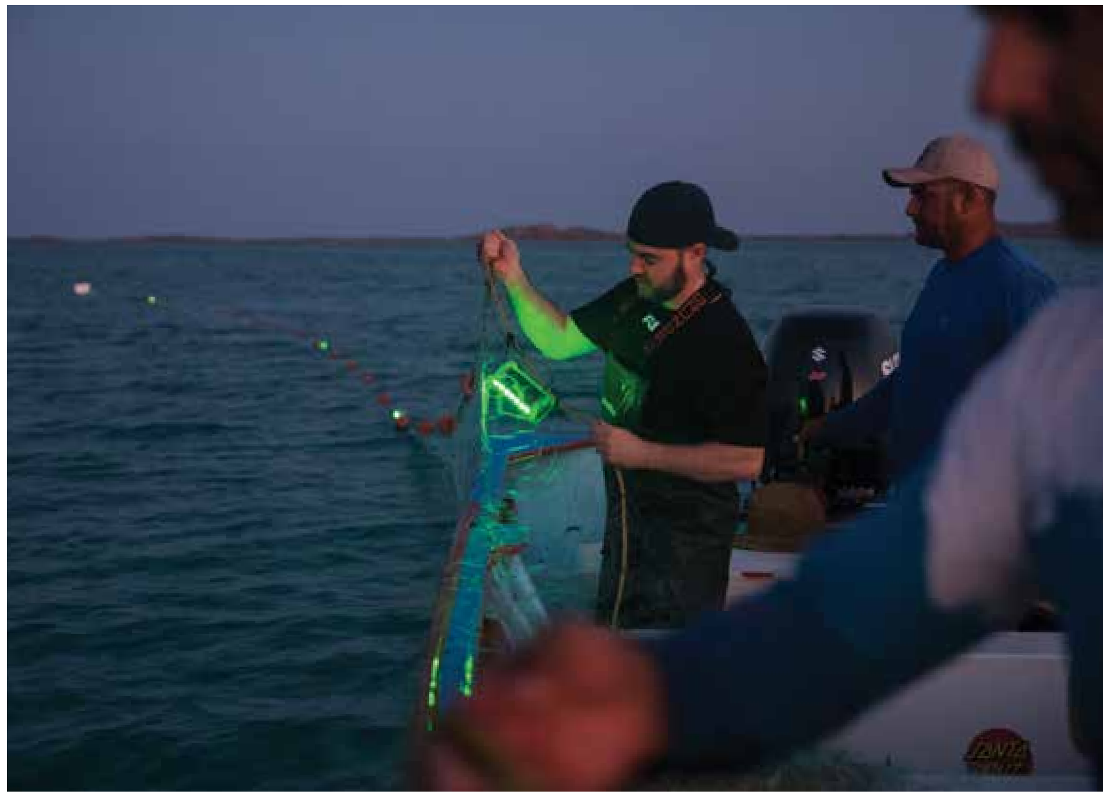
First, we decided to mimic the design of a float line buoy. The idea came from the first fisher workshop we held, where several fishers suggested we build a lighted buoy. The light is designed to be threaded onto the float line of a gillnet and is buoyant just like a traditional buoy. This method seamlessly integrates the technology into existing fishing gear, making it easy to use and therefore improving the likelihood that fishers would adopt it. Because the light system also functions as a buoy, it can offset the costs of actual buoys, which make up about 20 percent of the total cost of building a gillnet.

Second, to design a light that could remain illuminated longer than 12 to 24 hours without needing to be charged, we needed to make the light flash intermittently. We chose a moderate flash rate that we believed would still effectively illuminate the net for sea turtles—a flash rate between an emergency light and a street sign or roadwork light. The light that we developed can self-charge in sunlight and can be programmed to automatically emit either static or flashing light. Depending on the configuration, it can remain charged for up to one week after 30 to 60 minutes of charging in direct sunlight.

We chose a clear cylinder shape to house the LEDs because it required the least amount of change from a tube, which is similar to the midsection of a traditional float line buoy. This shape was also the most conducive to solar panel integration, and the end pieces of each tube were designed to create a shock absorbing effect. In contrast to existing LEDs, which require a complex locking mechanism to replace batteries, our design is sealed and can run for years without opening.

Instead of the AA batteries that are used in current LED-illuminated net designs, we used rechargeable cells that can hold more than 500 charge cycles, with a lifetime cost of roughly 1 cent per charge. This choice substantially reduces costs over nonrechargeable cells, particularly over an entire fishing season. Converting from AA battery power to solar also made the whole unit considerably lighter, and it eliminated the need for a sealed release mechanism, which can be difficult to maintain, and often has a cumbersome waterproof seal that needs to be opened and resealed with each battery exchange. Moreover, placing the LEDs in a buoy allowed us to substitute high-efficiency green LEDs that consume less power at the same light output.





PREVIOUS SPREAD: Fisher leader Juan Pablo Cuevas retrieves a solar-powered illuminated net at Isla El Pardito in the Sea of Cortez, Baja California Sur, Mexico. AT RIGHT: Arizona State University professor Jesse Senko (far right) activates a solar-powered light (left) on an illuminated net with fisher leaders Felipe and Juan Pablo Cuevas at Isla El Pardito in the Sea of Cortez, Baja California Sur, Mexico. ALL IMAGES: © Lindsay Lauckner Gundlock

STUDYING HOW SEA TURTLES REACT TO SOLAR-POWERED LIGHTED BUOYS

Following the design phase, during the summer of 2019 we tested the solar-powered buoys with flashing green lights. For the test, we chose entangling net fisheries off the Gulf of California coast of Baja California Sur, Mexico. Initial field experiments found that the solar-powered illuminated nets significantly reduced sea turtle bycatch rates, by 65 percent at night, a finding that is in line with previous studies of net illumination that used battery-powered, static green light. Most importantly, these field tests showed that the flashing lights also reduced sea turtle bycatch, a necessary step for harvesting solar energy and eliminating the need to actively recharge or change the lights. Overall, our fisher partners were pleased with how the lights performed. We are excited by these preliminary results, which suggest that solar-powered net illumination and the use of flashing lights represent a promising solution for mitigating sea turtle bycatch, with global applicability for passive net fisheries. To further evaluate the viability of the solar-powered buoys, we plan on testing the lights' effects on target fish catch and composition during the spring of 2020.

FUTURE DIRECTIONS

Now that we have developed a solar-powered light with a flash rate that is energy efficient and reduces sea turtle bycatch, we are working to make solar-powered net illumination more accessible on a global scale. This next phase includes partnering with industry and fishing communities to develop a range of improved lights that can be tested in global sea turtle bycatch hotspots and eventually implemented at scale. These lights will leverage new, high-efficiency solar cells that are being developed by Arizona State University's Solar Power Laboratory for SpaceX and NASA. Given their paper-thin width, light weight, and durability, these cells may allow us to develop a more streamlined buoy that is 30 percent to 50 percent smaller than the existing buoys while maintaining their current efficiency. •