A Plan to Reduce Sea Turtle Bycatch in Small-scale Gillnet Fisheries Using Illuminated Nets

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Table of Contents

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Abstract

Bycatch—the incidental capture of non-targeted species in fishing gear—threatens many different marine species. Fisheries bycatch threatens the continued survival of several sea turtle species, which have experienced population declines over the past several decades. New devices and gear modifications such as acoustic pingers, turtle excluder devices, and circle hooks have reduced the bycatch of marine mammals and sea turtles. Because sea turtles use visual cues to aid in foraging habits, methods that use visual deterrents to reduce incidental sea turtle capture in gillnets are an emerging research area. Past experiments have found that attaching light sources to gillnets reduces sea turtle bycatch without affecting target catch rates or catch market value; however, these methods were too costly and time-intensive to the fishers to be practical. This project will test the effectiveness of using illuminated nets to reduce sea turtle bycatch. Portions of the nets will be composed of a phosphorescent material that absorbs wavelengths of light and glows in the dark. The experiment will be carried out in summer 2010 in Punta Abreojos and Bahía de los Ángeles,

Baja California, Mexico. Students from underserved communities in San Diego will assist in data collection and analysis as part of the *Ocean Leaders Initiative* with the non-profit Ocean Discovery Institute.

SECTION I. BYCATCH: IMPACTS AND SOLUTIONS

Fisheries Bycatch

Fisheries bycatch—the incidental capture of non-targeted species in fishing gear—represents a significant problem for marine ecosystems. Due to lack of observer coverage and inaccurate catch reports, the true amount of global bycatch is difficult to predict. 38.5 million tons of non-targeted species are estimated to be caught annually by global fisheries, representing 40.4% of the annual global marine catch of 95.2 million tons (Davies et al. 2009). Quantifying bycatch solely by tonnage is problematic because bycatch of juvenile fish—which weigh less than adult fish—can reduce the amount of sexually mature individuals in a population. Bycatch is often discarded back to the sea, dead and unused, because the bycatch species is either protected by regulatory policies or commercially worthless. Bycatch is also a problem for fishers because it damages gear, takes time to remove from gear, and can result in depredation of target catch.

MARINE MAMMALS AND SEABIRDS

Bycatch threatens populations of protected, threatened, and endangered marine mammals and seabirds, particularly those that forage in areas with heavy commercial fishing pressure. Incidental capture in fishing gear is a major threat to whales, dolphins, and porpoises worldwide. Fisheries bycatch has resulted in the near-extinction of the vaquita in the Gulf of California (D'Agrosa et al. 2000). 653,365 marine mammals (307,753 cetaceans and 345,611 pinnipeds) are estimated to be caught as bycatch annually in global fisheries, mostly in gillnets (Read et al. 2006). All marine mammals are protected in United States waters by the Marine Mammal Protection Act, while 21 species are listed on the Endangered Species Act. These legislations forbid the intentional take of marine mammals and endangered species, but are powerless to prevent accidental captures in fishing gear. Bycatch also harms seabirds, particularly those with long life-spans and low reproductive rates, such as albatrosses and petrels. Tasker et al. (2000) estimate 265,000 birds were killed between 1996-1999 as bycatch in the Southern Ocean Patagonian tooth-fish fishery. As many as 44,000 albatrosses were killed annually during the 1990s in the Southern Ocean by the Japanese long-line tuna fishery (Brothers 1991).

Sea Turtles

Six of the seven species of sea turtle are listed as either Critically Endangered or Endangered by the IUCN (IUCN 2010). Anthropogenic threats to sea turtle populations include destruction of nesting beaches, pollution, poaching, and egg harvesting (Lewison and Crowder 2007). The North Pacific loggerhead (*Caretta caretta*) population has experienced a 90% decline in nesting females over the past three generations (Peckham et al. 2007). Pacific leatherback turtles (*Dermochelys coriacea*) have declined by 95% over the past 25 years (Spotila et al. 2000).

Although efforts have been made to protect sea turtles at their nesting beaches, the incidental capture in fishing gear still threatens their survival. Sea turtles are captured in pelagic long-line, trawl, and gillnet fisheries. In long-line fisheries, sea turtle mortalities result from the animal either drowning after becoming hooked or suffering fatal injuries onboard the vessel from swallowing the hook. Lewison et al. (2004) quantified sea turtle bycatch in pelagic long-line fisheries. They calculated a total of 1.4 billion hooks set by the fishing fleets of 40 nations during the year 2000. The rate of sea turtle bycatch on the vessels ranged from 0-14 loggerheads and 0-2.4 leatherbacks for every 1000 hooks. For the global long-line fleet in 2000, the authors estimated as many as 220,000 loggerheads and 50,000 leatherbacks were caught as bycatch. It is unclear how many mortalities occur as the result of long-line bycatch; the U.S. National Marine Fisheries Service (NMFS) estimates a bycatch mortality rate of 17-42% for loggerheads and 8-27% for leatherbacks (NMFS 2001a).

Because net entanglement can lead to drowning, sea turtles caught in gillnets and trawls face a higher chance of mortality than those captured on a long-line hook—gillnet mortality of sea turtles has been observed at greater than 50% (Lewison and Crowder 2007). Peckham et al. (2007) observed a 73% mortality rate of sea turtles caught in coastal gillnets off Mexico. Local (artisanal) fisheries, which are poorly documented and observed, are globally ubiquitous and may account for at least 95% of the world's fishers (Pauly 2006). Peckham et al. (2007) calculated a minimum of 1000 loggerhead turtles died as the result of bycatch in two observed Mexican artisanal gillnet fisheries; this figure is comparable with mortalities caused by industrial pelagic long-lining fleets.

Bycatch Reduction Gear Modifications

Given the threats to marine species populations from incidental capture by fishing gear, fisheries managers are tasked with devising methods to reduce bycatch. Some methods include fisheries time/area closures and catch limits; certainly, reducing fishing pressure will likely reduce bycatch, but the political processes behind fisheries management decisions may take too long to save some critically endangered bycatch species. The facilitation of fisheries closures in other nations, especially in artisanal fisheries, could encounter additional political roadblocks.

This section will focus strictly on gear modifications and new devices. Successful gear modifications should not only reduce bycatch, but also must maintain target catch levels and fisher revenue. Modifications should also not raise operation costs or require extra time or effort to install and use. Most fishers have an incentive to embrace new technologies that could potentially reduce gear damage from bycatch as well as the time and effort spent handling bycatch.

ACOUSTIC PINGERS

Acoustic alarms, or "pingers," have been installed on fishing nets to reduce marine mammal bycatch. Pingers emit noises at specified frequencies that interfere with marine mammal foraging by deterring them from approaching the gear. An experiment by Kraus et al. (1997) placed both active and inactive pingers on gillnets in an area within the Gulf of Maine that supported both an active fishery and a large population of harbor porpoises. The active pingers, which emitted a 300 ms pulse every four seconds, reduced harbor porpoise bycatch by 90%. Barlow and Cameron (2003) attached pingers to nets within the California driftnet fishery and found nets with pingers captured one-third as many marine mammals as did nets without pingers.

Some fishers oppose acoustic pingers, citing factors such as high cost, periodic maintenance, and interference with setting and hauling gear (Bache 2003). Compliance with pinger regulations is also weak: in the Gulf of Maine, compliance ranges from 38% to 91% (Bache 2003). Enforcement of pinger use can be difficult—the agency responsible for enforcement in the United States, the Coast Guard, lacks the means to haul nets and thus cannot check for the presence of pingers when nets are set (Bache 2003).

Turtle Excluder Devices

Turtle excluder devices (TEDs) are tools designed to reduce sea turtle bycatch—particularly loggerhead and Kemp's ridley (*Lepidochelys kempii*)—in shrimp trawl fisheries. In 1990, it was estimated that as many as 44,000 sea turtles were killed annually by the U.S. shrimp trawl fleet (Magnusson et al. 1990). A TED is a metal grid of bars built into the net that directs sea turtles out of the net through a trap door, allowing shrimp to pass through the bars into the back of the net (Figure 1). When TEDs were first mandated in the U.S. shrimp trawl fishery in 1992, the devices were expected to reduce the incidental capture of sea turtles by 97% (Henwood et al. 1992). The actual results of TEDs have been mixed. Stranding rates of apparently healthy, injury-free sea turtles on beaches give accurate estimates of bycatch mortality rates (Lewison et al. 2003). In the first three years following the mandatory implementation of TEDs, stranding rates of loggerhead and Kemp's ridley turtles in the Gulf of Mexico and Southeastern U.S. decreased (Lewison et al. 2003). Since then, stranding rates have increased, possibly due to improper use of TEDs, inadequate size of TED openings, or poor TED compliance (Lewison et al. 2003). Evidence suggests adult loggerhead sea turtles are larger now than they were in 1992, when the mandatory size proportions of TEDs were first determined; thus, expanding the size of TEDs could result in fewer loggerhead sea turtle mortalities in shrimp trawls (Epperly and Teas 2002).

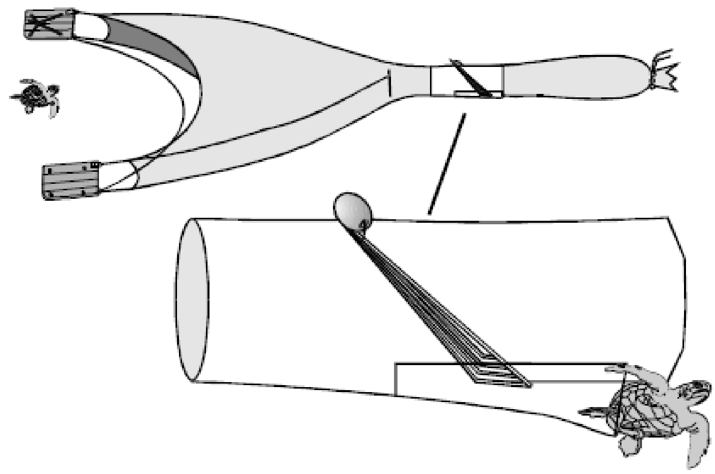

Figure 1. Turtle Excluder Device (TED) used in shrimp trawl fisheries.

CIRCLE HOOKS

Circle hooks are alternatives to the traditional J-shaped hooks used in long-line fisheries. Long-line vessels trail a string of baited hooks, sometimes as long as 100 km, at or near the sea surface to catch large pelagic fish such as tunas and swordfish. Although more selective than net fisheries, long-lining still results in bycatch of species of seabirds and sea turtles that prey on the bait attached to the hooks. Long-line fisheries have traditionally used J-hooks; the main difference between a J-hook and a circle hook is that the tip of a circle hook curves to point back toward the hook shaft, resulting in a wider hook with a smaller gap between the shaft and the tip (Figure 2). The hooks reduce sea turtle mortality by hooking the turtle in the mouth rather than deeper in the throat or stomach, allowing fishers to unhook the turtles without causing serious injury or mortality (Gilman et al. 2006). It is important to note that circle hooks are only effective in shallow-set long-line fisheries; in deep-set fisheries, a turtle hooked in the mouth will still drown.

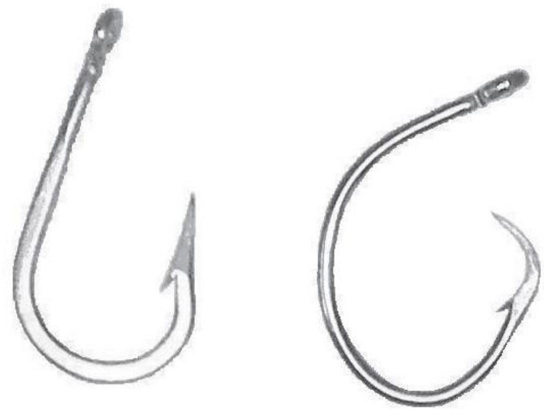

Figure 2. J-hook (left) and circle hook (right) used in pelagic long-line fisheries

Watson et al. (2005) conducted an experiment to analyze the effectiveness of circle hooks at reducing sea turtle bycatch in the North Atlantic U.S. long-line swordfish fishery. Their results indicated using circle hooks instead of J-hooks reduced incidental capture of loggerhead sea turtles by 90%. Of the loggerheads captured on J-hooks, 68% swallowed the hook, while circle hooks were swallowed by 27% of loggerheads. The study also concluded that using circle hooks in conjunction with fish bait instead of squid bait further reduced sea turtle capture rates. Gilman et al. (2007) analyzed sea turtle capture rates in the Hawaii-based long-line swordfish fishery after regulations were put in place mandating the use of circle hooks. They found circle hooks reduced loggerhead and leatherback capture rates by 90% and 83%, respectively, without compromising target catch rates.

Sea Turtle Vision

Successful mechanical modifications to gear have reduced bycatch, but some methods are gear-specific, such as circle hooks, which are only relevant for long-line fisheries. Improving knowledge about the sensory cues that attract species to baited hooks or nets can facilitate new methods for preventing bycatch in other gear types. Some studies have examined the visual properties of sea turtles with a goal of discovering the role visual cues play in sea turtle foraging habits.

A review by Southwood et al. (2008) analyzed the visual abilities of sea turtles and the species of pelagic fish targeted by long-line fisheries to apply knowledge of vision toward bycatch reduction strategies. The review found that the pairing of visual pigments with various types of oil droplets in the eyes of green (*Chelonia mydas*) and loggerhead turtles provides these species with a greater capacity for color discrimination than pelagic fishes; the visual acuity of leatherback turtles appears to be less developed. That sea turtles can distinguish color leads to interesting bycatch mitigation ideas. The use of blue-dyed bait has shown to reduce seabird bycatch in pelagic long-line fisheries as well as increase target catch rates (McNamara et al. 1999); in laboratory experiments, 98% of loggerhead turtles also preferred non-treated squid bait to blue-dyed squid bait (Swimmer et al. 2005). In contrast, results of field trials on long-lining vessels demonstrated that green and olive ridley (*Lepidochelys olivacea*) sea turtles showed no preference for non-treated bait over blue-dyed bait (Swimmer et al. 2005)

Pelagic long-line fisheries often attach glowing lights near baited hooks to attract target fish species. Laboratory studies have indicated juvenile loggerhead sea turtles are attracted to glowing green, blue, and yellow chemical lightsticks, as well as orange light-emitting diodes (LEDs) (Wang et al. 2007; Moein-Bartol et al. 2002). Laboratory studies suggest both loggerhead and green sea turtles are able to detect ultraviolet light, while pelagic fishes cannot. The presence of different types of visual pigments in the photoreceptors of pelagic fishes suggests the ability for color perception, although the extent of color perception is dependent on the depth of a fish's foraging habitat.

<u>Section II. Ocean Discovery Institute: Connecting Students with the Ocean</u>

This study will investigate alternative methods to reduce sea turtle bycatch in small-scale gillnet fisheries. Field experiments will be conducted in the Gulf of California and on the Pacific coast of Baja California, Mexico, to test the effectiveness of using illuminated nets to reduce green sea turtle bycatch without affecting target fish catch rates. Through the facilitation of Ocean Discovery Institute, this project will be conducted, under the author's leadership, by a team of five underserved high schools students from the City Heights community of San Diego, California.

Ocean Discovery Institute's Mission

This research project is conducted in partnership with the San Diego-based 501(c)3 nonprofit organization Ocean Discovery Institute (www.oceandiscoveryinstitute.org). Founded in 1999, Ocean Discovery Institute uses science exploration to engage young people from urban and diverse backgrounds in education, scientific research, and environmental stewardship. Through its programs and services, more than 30,000 young people have been empowered to transform their lives and make a difference in the world as scientific leaders.

The mission of Ocean Discovery Institute is to engage, educate, and inspire youth from urban and diverse backgrounds through science-based exploration of the ocean and nature, preparing them to be tomorrow's scientific and environmental leaders. Its vision is to empower urban and diverse young people to protect the ocean and natural environment, improve the health of local communities, and strengthen the quality of life in the world.

Ocean Discovery Institute leverages an extraordinary educational resource intrinsic to San Diego—the ocean and coast. Its fundamental belief is that all of the primary concepts in science can be taught through ocean science, including: mathematics, engineering, physics, biochemistry, geology, astronomy, ecology, physiology, molecular/biotechnology, environmental sciences, technology/computer science, and biomechanics. Using the ocean as an educational tool capitalizes on young people's instinctive attraction to the sea and builds knowledge of the planet's defining feature.

Each year, Ocean Discovery Institute engages approximately 4,500 young people in tuition-free science experiences. To ensure continued effectiveness and enhancement, regular program assessments are conducted by a professional external evaluator.

The *Ocean Leaders Initiative* is a collaboration between Ocean Discovery Institute, University of San Diego, National Oceanic & Atmospheric Administration, Scripps Institution of Oceanography, and many secondary partners. Evaluation and tracking data demonstrate gains at every level, including a significant increase in students spending time in nature, attending college, and majoring in science and conservation. The *Ocean Leaders Initiative* is part of a larger strategy that provides science and nature experiences to underserved students and their families.

The *Ocean Leaders Initiative* is designed to provide urban and diverse students with a comprehensive ocean experience that is designed for multi-year participation and is based in programmatic components and support services that are developed to ensure each student participant has a strong understanding of the ocean sciences and the capabilities to move their education and career forward. As part of this structure, the initiative will include a series of programs that act as building blocks in the students' ocean science education development as they grow from sixth to twelfth grade. Beyond programmatic components, the initiative is multi-systemic and provides sixth grade through college students with a support structure to ensure their ability to pursue an education and career in science and conservation.

The third program of the *Ocean Leaders Initiative* will provide high school students with an intensive, field-based, research experience that in part takes place at a field site in Baja California, Mexico. Older 11^{th} and 12^{th} grade students will be paired with the younger 9^{th} and 10^{th} grade students to act as mentors. The younger students will use their linguistic and cultural strengths to assist their non-Spanish speaking mentors and scientists working with the program.

These students will spend several weeks in the spring preparing for an intensive research experience. They will study ocean science concepts and develop skills in the classroom, lab and field. During this time the students will also learn to swim and snorkel in order to make observations of the marine environment and collect data. Following this intensive preparation, the students in this third program will spend five weeks living and conducting marine science-focused research projects alongside scientists from universities and government agencies, at a field research station located on the Sea of Cortez in Baja California, Mexico. Students will be split into three research groups, conducting experiments on fisheries (Pesca), wetlands, or islands. The students will then return to San Diego where they will spend three weeks preparing presentations and posters so that they may disseminate their research findings. Students will present their research findings and experiences at a local annual event as well as professional meetings.

This Capstone project is also the Pesca Directed Research Project for Summer 2010 in Baja California, Mexico. Data collection will be carried out by a team of five high school students participating in *Program 3* of the *Ocean Leaders Initiative*. Appendixes A and B, the Concept Map and the Directed Research Plan, are additional components of the Pesca Project. The Directed Research (DR) Plan is a guide to explain the background, objectives, and methods of the project for the students. Its purpose is to outline the progression of the scientific method for the students—none of whom have any formal scientific training—in a clear, logical fashion. The DR Plan is a series of repeated patterns and questions: it states the objective of the project; asks the main question the project is trying to answer; asks the sub-questions required to help answer the main question; and spells out the methods involved in answering the sub-questions. This pattern is presented first in the Introduction in narrative form and then again in the Methods section in a more specific format. Following the format of the DR Plan will help the students maintain a "big-picture" vision of the project while also understanding the process of how a scientific question is answered. The Concept Map is another example of the scientific method pattern, only displayed in a different format that enables the students to visualize the steps needed to complete the objective of the project.

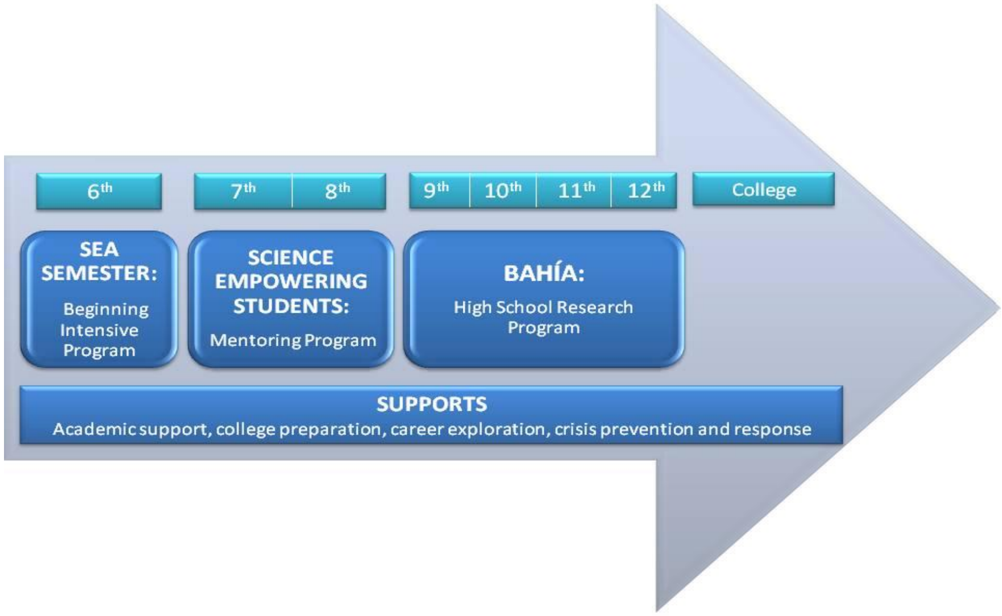

Figure 3. Student progress through the after-school programs of Ocean Discovery Institute

Previous Ocean Discovery Institute Sea Turtle Vision Experiments

Beginning in 2005, Ocean Discovery Institute has partnered with NOAA's Pacific Island Fisheries Science Center and the University of Hawaii's Joint Institute for Marine & Atmospheric Research to identify new strategies to reduce bycatch of sea turtles. The work has focused on two strategies to reduce sea turtle bycatch: shark shapes and illumination.

Shark Shapes

Wang et al. (2009) tested the use of shark shapes as a visual deterrent (similar to a scarecrow concept) to reduce green sea turtle bycatch. Tests of green sea turtle capture rates were conducted along the Pacific coast near Punta Abreojos, Baja California, Mexico, in conjunction with ongoing green turtle population surveys. The experimental nets featured a black shark silhouette shape suspended in front of the net, while the control nets had no shark shape (Figure 4). The results demonstrated a significant reduction of green sea turtle interactions with nets by 54% (Figure 5).

To test the effects of shark shapes on catch rates of target fish species, experimental nets were paired with control nets in an existing artisanal demersal gillnet fishery in the Gulf of California in Bahía de los Ángeles, Baja California, Mexico. The nets with shark shapes showed significant decreases of target catch CPUE by 45% and mean catch value by 47.4% (Figure 5). These decreases mean shark shapes are not practical for further consideration in the fishery, but they may have other useful implications, such as deterring sea turtle entry from areas such as power plant intake plants.

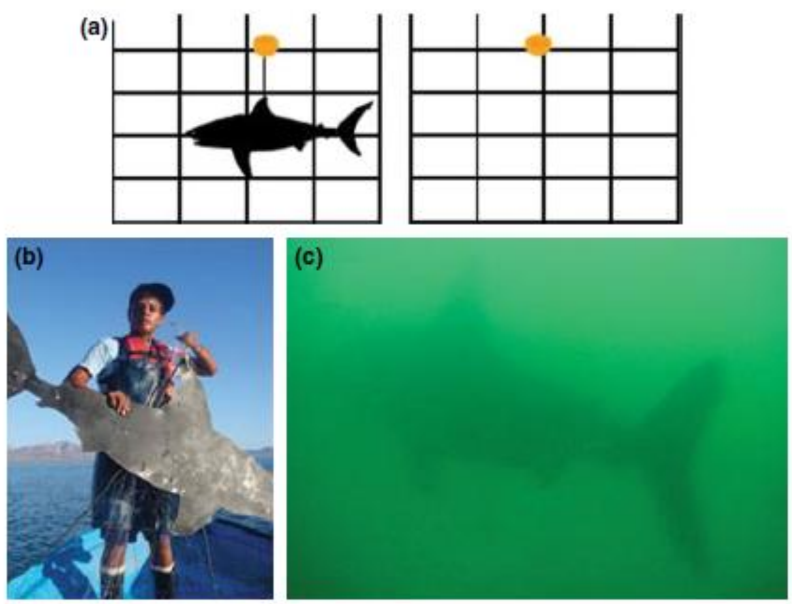

Figure 4. (a) Schematic of experimental nets with shark shape suspended in front of the net. (b) Shark shape displayed by Ocean Discovery Institute student. (c) Shark shape as viewed in an underwater environment.

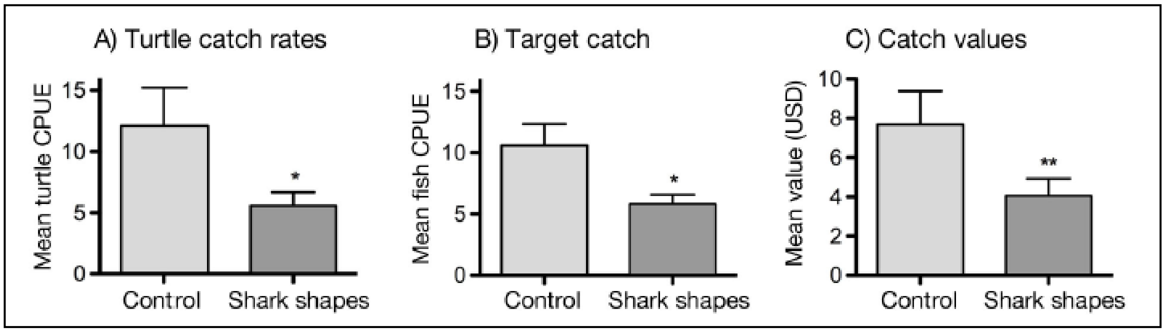

Figure 5. Effects of deploying shark shapes on green sea turtle catch rates, target fish catch, and catch value using control nets versus experimental nets.

Illumination

Wang et al. (2009) tested the use of illumination to reduce green sea turtle bycatch by attaching light sources to nets. Two different light sources were tested: LEDs and chemical lightsticks (Figure 6). The methods were similar to those of the shark shape experiments, except the experiments were conducted at night. Illuminating gillnets with LEDs at night resulted in a significant reduction of green sea turtle captures by 40% (Figure 7). Illumination experiments with LEDs demonstrated no significant difference between the mean CPUE of target species caught on the experimental and control nets (Figure 7). Similarly, LED-illuminated experimental nets demonstrated no significant difference in mean market value from the control nets (Figure 7). Using lightsticks reduced sea turtle captures by 59%, with no significant difference in CPUE of target species or mean market value (Figure 8).

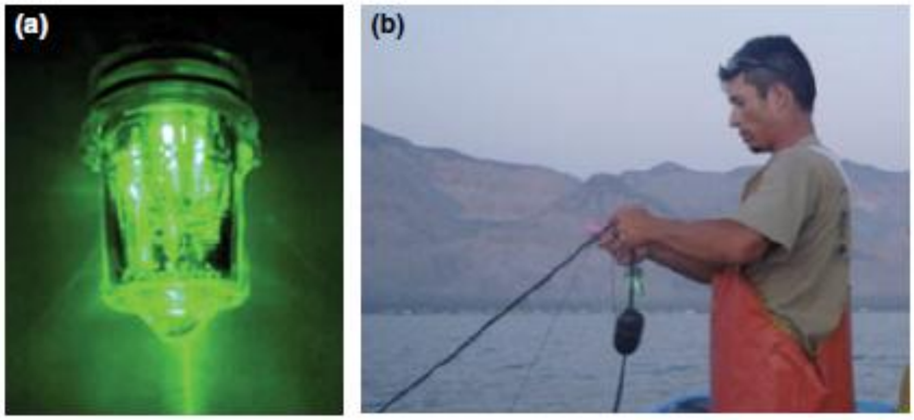

Figure 6. (a) Green light-emitting diode (LED) used on the experimental nets. (b) Fisherman attaching an LED to the float-line of a demersal gillnet in Bahía de los Ángeles.

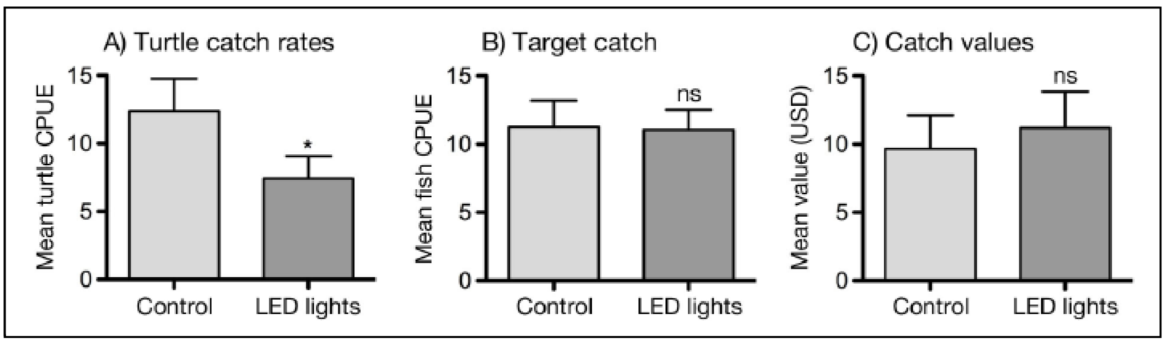

Figure 7: Effects of LED light illumination on green sea turtle catch rates, target fish catch, and catch values using control nets versus experimental nets.

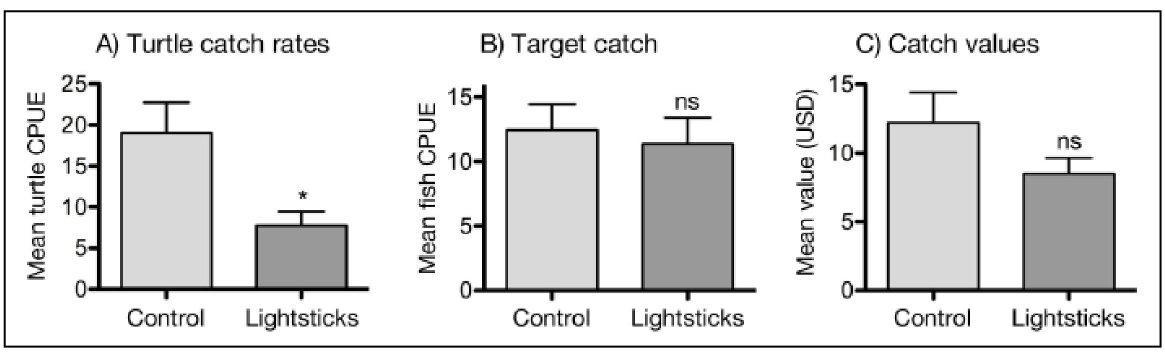

Figure 8: Effects of lightstick illumination on green sea turtle catch rates, target fish catch, and catch values using control nets versus experimental nets.

In addition, surveys were conducted with each participating fisherman and a focus group to understand fishermen perceptions of the potential for adopting these methods. Survey and focus group results revealed that fishermen believe LEDs are potentially viable strategies. LEDs were perceived as easy to use and may even increase desirable catch. However, concerns were raised over the cost of batteries to operate the LEDs and the time and effort needed to attach the lights. While the lightsticks also resulted in no reductions of target catch, it was noted that using lightsticks generates a large amount of waste and is time-intensive to the fishermen.

SECTION III. PHOSPHORESCENT NETS

2010 Pesca Directed Research Project

This year's project will take into account the results from Ocean Discovery Institute's previous experiments (Wang et al. 2009) to test a new method of illumination that is more practical and cost-effective than LEDs and lightsticks. Illumination with LEDs and lightsticks has demonstrated to reduce green sea turtle bycatch rates without affecting target catch rates or market value, but both methods had flaws that would prohibit fishers from incorporating them into the fisheries.

Both methods required the fishers to manually attach the light device to the net as the net was set. Lightsticks and LEDs were spaced five and ten meters apart, respectively, on 400 meter nets, so fishers had to attach between 40 to 80 lights to the net; the process was too time-intensive to be practical. The lights are also too costly for use in an artisanal fishery, where catch values are low. Lightsticks range between $0.10 to $1.00 per lightstick and the initial costs are substantially cheaper than battery-powered LED lights, which can range from $10 to $40 each. Lightsticks, however, only produce light for up to 24 hours, while the LEDs can remain continuously illuminated for over 1 month. Lightsticks offered an initially less expensive illumination method, though over an entire fishing season battery-powered LED lights may become more cost effective and will result in less plastic waste. In the case of these experiments, the costs of lightsticks ($60/net) and LEDs ($1400/net) are cost-prohibitive for the fishery in Bahía de los Ángeles.

In 2010, portions of the net will be created out of phosphorescent materials, eliminating the need to attach each light individually. The phosphorescent parts of the net will include the buoys that float the top of the net to keep it vertical in the water column, the float line (the line running horizontally along the top of the net), and the lead line (the line running horizontally along the bottom of the net) (Figure 9).

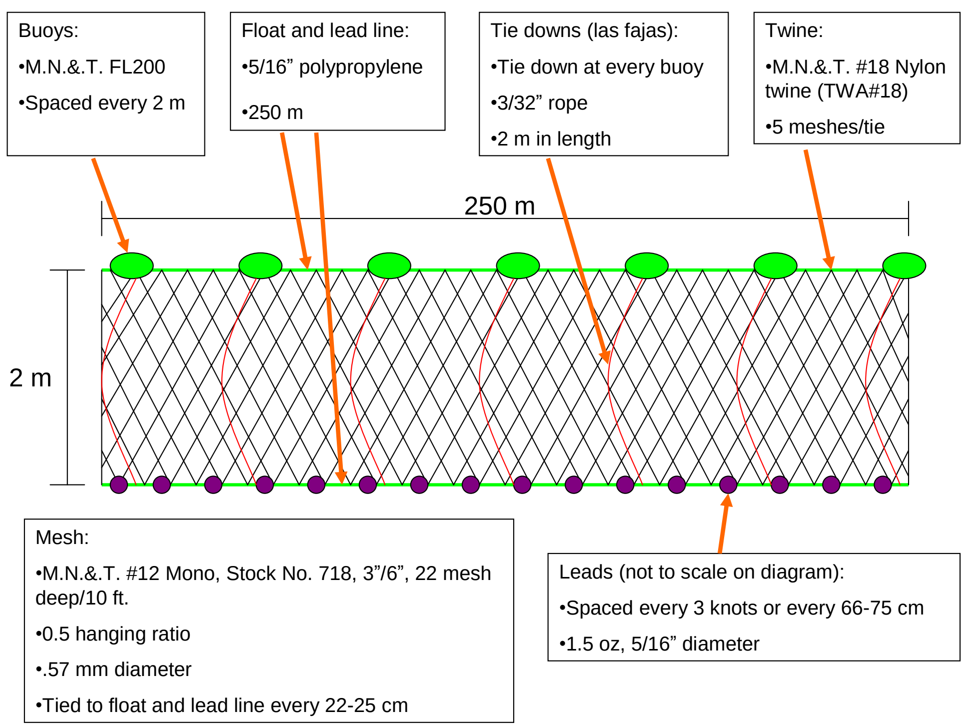

Figure 9. Diagram showing experimental gillnets. Phosphorescent materials are highlighted in green. Buoys, twine, and mesh supplied by Memphis Net and Twine (M.N.&.T.) Co. Float and lead lines supplied by Genesis Light Line, LLC. Lead weights supplied by Harbor Marine Fishing Supplies.

The buoys are FL200 buoys supplied by Memphis Net and Twine Co. They will be coated with paint containing LumiNova, a phosphorescent 10-40 micron pigment produced by Nemoto & Co. LumiNova is a non-toxic strontium aluminate-based pigment that is charged by any light in the wavelength band from 250-450 nm. The pigment should glow continuously throughout the nighttime experiment period. The float and lead lines are 5/16" polypropylene supplied by Genesis Light Line, LLC. These glowing lines are part of the Genesis GloRope Dyneema product line, intended for nighttime maritime rescue operations.

Experiments were conducted to determine the best method to coat the buoys with paint containing the phosphorescent pigment. Various combinations of coats of white primer, the phosphorescent paint, and a waterproof clear coat were applied to the buoys. After one week inside a tub of water, the phosphorescent paint peeled away from the primer on each buoy. It was determined that the buoys could be most durably painted by an industrial paint company; thus, Chris Industries, Inc. was contracted to coat the float buoys with the phosphorescent paint.

Because these nets eliminate the need to attach light sources, the fishers can set the nets as they would set a normal net, saving time and effort. However, the price of the illuminated nets is still too high for the nets to be realistically adopted into the fishery. At $2.33/foot, the GloRope float and lead lines will cost approximately $5,200 for a 400 meter net.

The companies that produce these materials do not intend them to be used in commercial fisheries. An important next step, assuming that the experiments demonstrate a beneficial effect of this technology in reducing sea turtle bycatch without negatively affecting the catch of target fishes, will be finding a corporation to mass-produce these materials for the express purpose of being used in gillnet fisheries. If these illuminated nets can reduce sea turtle bycatch without affecting target catch rates—and without requiring any extra time or effort by the fishers—it is important that the production costs of the materials decrease to a level that is cost-effective for artisanal fisheries.

To further investigate the practicality of this bycatch reduction method, a survey will be conducted with fishermen and other citizens of Bahía de los Ángeles (Appendix C). The goals of the survey are to ask the fishermen's opinion on problems created by bycatch, find out their thoughts on incorporating illuminated nets into their fishery, and record their thoughts on other potential solutions to reducing bycatch. The fishermen are a source of practical knowledge, having spent infinitely more time on the waters of Bahía de los Ángeles than anyone else, and can offer an alternative perspective that may prove extremely valuable.

Conclusions

A silver bullet to solve the world's fisheries bycatch problems does not exist. The only definite way to stop bycatch is to stop fishing—that, of course, is unrealistic. As human populations continue to grow, the world will continue to depend on fish as an important protein source. Sea turtles will always forage in areas where humans are setting nets and long-lines; the turtles will not change their behavior, but fisheries can. Preventing bycatch requires creativity. The circle hooks used in long-line fisheries are a clear example of a simple gear modification that significantly reduces bycatch without imposing on fisher effort or revenues.

Creating gillnets that glow in the dark is another creative solution. The structure and function of the nets does not change, nor does the daily routine of the fisher. For this project, a great amount of time and effort was spent researching different net materials in order to accumulate and combine all the necessary luminescent parts. This process could be streamlined by a single company dedicated to producing the materials in an efficient manner. If the illuminated nets prove to be an effective bycatch deterrent, they will create incentives for fishers who seek to save money, time, and effort by reducing bycatch in their nets.

Given the recent and continuing declines in sea turtle abundance, conserving the species will be a task for both current and future generations of scientists. Low-income students of color are underrepresented in the sciences because of both a lack of opportunities and also life obstacles beyond their control. This project gives high school students the valuable scientific research experience they may not receive at school. By providing underserved students with such an opportunity, this project lays the foundation for the students to pursue advanced education and careers in scientific research. Ideally, the alternative background of the students will provide the scientific community with imaginative ways to deal with fisheries bycatch and other problems threatening the world's oceans.

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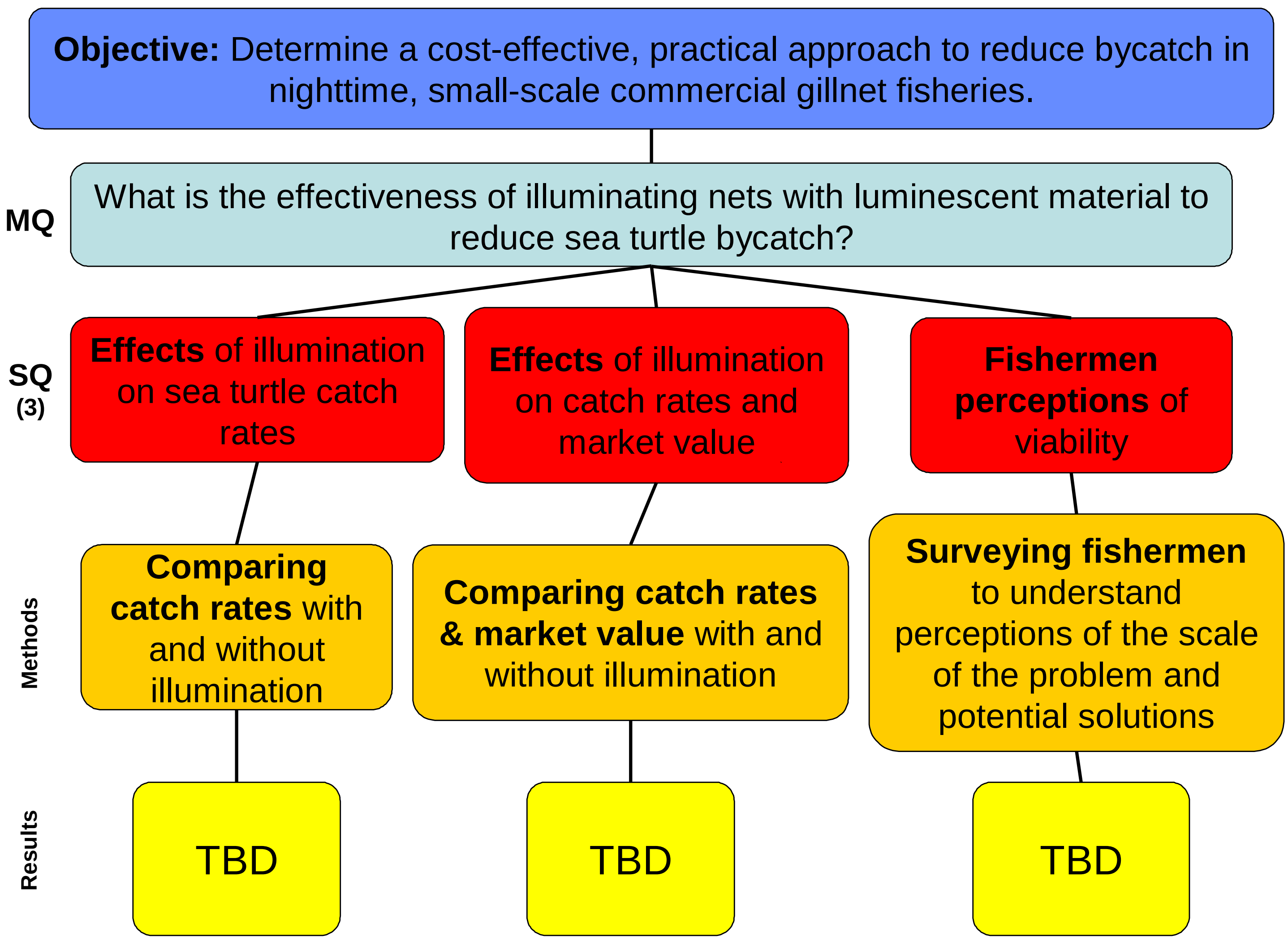
Appendix A: Concept Map



Appendix B: Directed Research Plan

Determining a cost-effective, practical approach to reduce bycatch in nighttime, small-scale commercial gillnet fisheries

Primary Participants

- Researchers: Dr. John H. Wang, University of Hawaii, JIMAR; Dr. Yonat Swimmer, NOAA National Marine Fisheries Service; Shara Fisler, Ocean Discovery Institute
- Directed research/education leader: Joel Barkan, Ocean Discovery Institute
- Ocean Discovery Institute Students: Maria Puga, Cielo Corado, Carlos Rodriguez, Richard Alvarez, Diem Tran-Hong
- Ocean Discovery Institute & NOAA fellows, staff, assistants, and associates including: Santos Sillas, Khan Chi Damn, Anne Correia, Melissa Katigbak, T. Todd Jones, Christina Fahy, Dan Lawson
- Bahía de los Angeles Fishermen including: Basilio Navarro Verdugo (Panga: Bonita, Ayudante: Eric Navarro Verdugo), Francisco “Pancho” Verdugo Leree (Panga: Marlin II, Ayudante: Efrain “Cury” Cordero Rubio), Hector Morales Romero (Panga: Brisa, Ayudante: Hector Morales Arce), Roberto Ocaña Fuerte (Panga: Isaac III, Ayudante: Efren Ocaña Fuerte)
- Punta Abreojos Fishermen including: Armando Camacho Liera, Irubiel “Tulino” Patrón de la Toba, Miguel Valenzuela Zuniga, Felipe Valenzuela Zuniga

Collaborators

Carlos Ramón Godinez Reyes - CONANP, Ensenada, Baja California, México
Dr. Exequiel Ezcurra – UC Mexus

Project Dates

- Research Timeframe: June 27, 2010 – October 1, 2010
- Experiments in Bahía de los Angeles: June - July, 2010
- Experiments in Punta Abreojos: July 3-6, September 1-4, 2010
- Analysis, presentation, and write up: August 1- April 30, 2010

Project Overview

INTRODUCTION:
Global fisheries catch an estimated 95.2 million tons of fish each year (Davies et al. 2009). Fish is an important and inexpensive food resource for billions of people, especially in developing nations. Coastal economies are dependent on fisheries and millions of people around the world make a living from fishing. As many as 95% of all the world’s fishers are employed in small-scale or subsistence fisheries (Pauly 2006).

Although humans rely on fisheries for food and income, fisheries also create problems for the marine environment. One such problem is bycatch, or the incidental capture of non-target species in fishing gear. Fisheries bycatch affects multiple species of fish, birds, marine mammals, invertebrates, and sea turtles in all the world’s oceans.

Bycatch of sea turtles in gillnet and longline fisheries has resulted in negative impacts on sea turtle populations, the oceanic food web, and commercial fisheries (Lewison et al. 2004; Lum 2006; Peckham et al. 2007). Efforts have been made to reduce sea turtle bycatch rates with gear modifications and stricter fishing regulations (Gilman 2006).

Sea lion bycatch in commercial fisheries represents a problem to both the species population abundance as well as to fishermen in the form of damaged gear and time spent releasing the bycatch. Unregulated gillnet fishing in the Gulf of California has doubled in the past decade, which may be affecting California sea lion populations (Barlow et al. 2008). The kill rate of California sea lions in gillnets is estimated at 0.10 sea lions/net in the Gulf of California (Underwood et al. 2008).

Addressing the bycatch problem requires a collaborative effort among scientists, fishers, and fishery managers. Over the past five years, Ocean Discovery Institute has partnered with NOAA's Pacific Island Fisheries Science Center and University of Hawaii's Joint Institute for Marine & Atmospheric Research to conduct research on bycatch reduction. Our goal is to devise a method that reduces bycatch, maintains target catch rates and market value, and would be practical and readily adoptable into a small-scale commercial gillnet fishery.

PROJECT HISTORY:
Our primary work from 2005-2009 has focused on two strategies to reduce sea turtle bycatch: shark shapes and illumination.

Shark shapes: We tested the use of shark shapes as a visual deterrent (similar to a scarecrow concept) to reduce sea turtle bycatch. Our results demonstrated a significant reduction of sea turtle interactions with nets by 54% (Wang et al. 2010; Figure 1). At the same time, the nets with shark shapes also showed significant decreases of target catch CPUE and mean catch value (Figure 1). Therefore, this strategy is not practical for further consideration in the fishery but may have other useful implications, such as deterring sea turtle entry (for example, near power plant intake pipes).

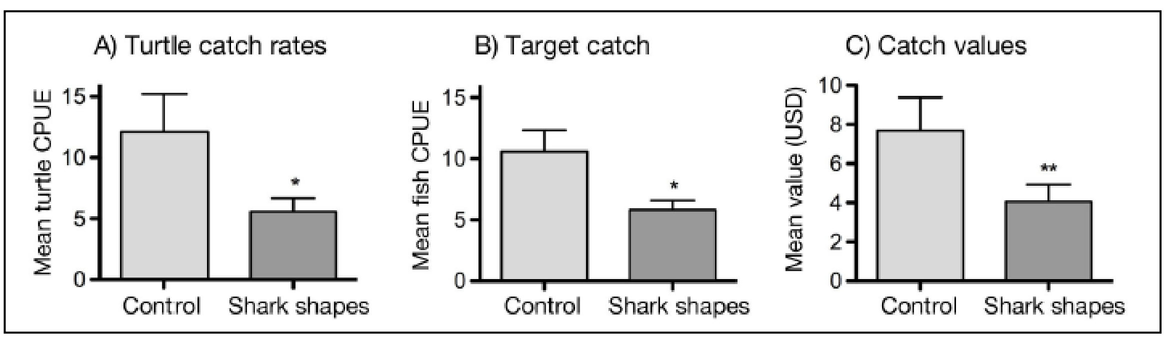


Figure 1: Effects of deploying shark shapes on green sea turtle catch rates, target fish catch, and catch value using control nets versus experimental nets.

Illumination: We tested the use of illumination to reduce sea turtle bycatch by attaching light sources to nets. We have tested two different light sources: light emitting diodes (LEDs) and chemical lightsticks. Illuminating gillnets with LEDs at night resulted in a significant reduction of sea turtle captures by 40% (Wang et al. 2010; Figure 2). Illumination experiments with LEDs demonstrated no significant difference between the mean CPUE of target species caught on the experimental and control nets (Figure 2). Similarly, illuminated experimental nets demonstrated no significant difference in mean market value from the control nets (Figure 2). Using lightsticks reduced sea turtle captures by 59%, with no significant difference in CPUE of target species or mean market value (Wang et al. 2010; Figure 3). Therefore, this strategy and modifications of it are worth further consideration in the fishery.

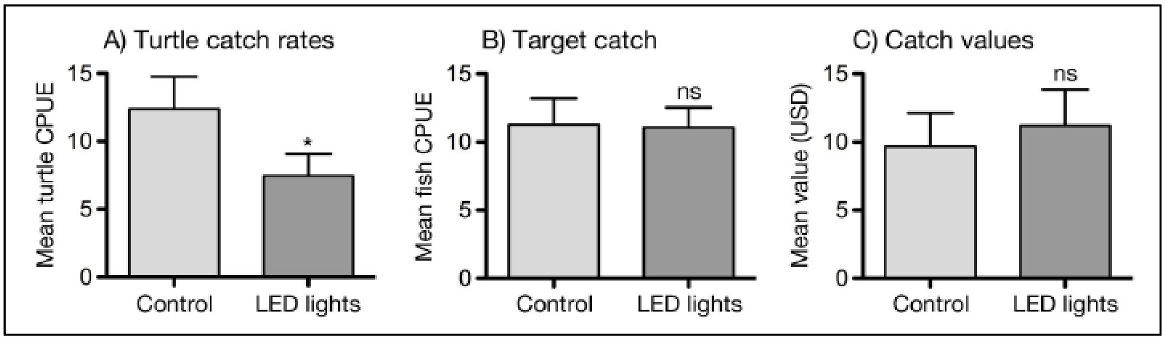


Figure 2: Effects of LED light illumination on green sea turtle catch rates, target fish catch, and catch values using control nets versus experimental nets.

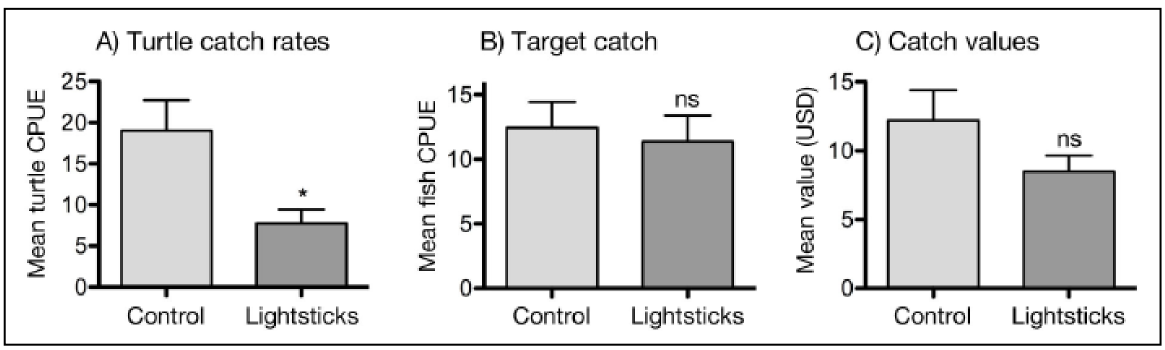


Figure 3: Effects of lightstick illumination on green sea turtle catch rates, target fish catch, and catch values using control nets versus experimental nets.

In addition, we facilitated surveys with each participating fisherman and a focus group to understand fishermen perceptions of the potential for adopting these methods. Survey and focus group results revealed that fishermen believe illumination is a potentially viable strategy. Illumination was perceived as easy to use and that LEDs may even increase desirable catch. However, concerns were raised over cost of batteries to operate the LEDs, the cost of purchasing light sources, and the time and effort needed to attach the lights. In addition, it was noted that using lightsticks generates a large amount of waste.

2010 OBJECTIVE

During summer 2010, we plan to build off what we have learned from previous experiments to further investigate a practical, cost-effective approach to reducing bycatch in gillnet fisheries using illumination; we hope this strategy will mitigate some of the problems associated with previous illumination strategies. We have identified a luminescent pigment that absorbs solar energy and emits solar radiation and will apply this pigment to some of the net materials to create a net that glows in the dark (Figure 4).

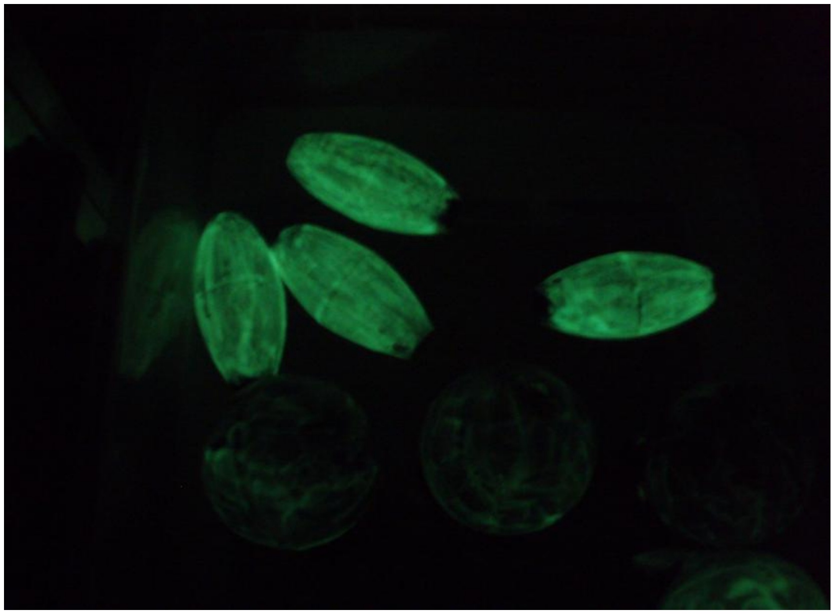


Figure 4: Buoys coated with paint containing the luminescent pigment.

The summer project will test the effectiveness of luminescent nets to reduce sea turtle bycatch in gillnets. In order to be effective, the net must reduce the bycatch of sea turtles while maintaining target catch rates and market value. We hope to devise a method that is practical, cost-effective, and can be adopted into small-scale commercial gillnet fisheries. We will use the valuable resource of the fishermen and other community members in Bahia de los Angeles to learn more about their perceptions of this new method's viability.

Sea lion researchers have indicated that sea lions may be captured in gillnets because the animals have trouble seeing the nets. Therefore, we will conduct experiments in winter 2010 to test the effects of luminescent nets on reducing sea lion bycatch. From personal communication with fishermen in Bahia de los Angeles, we have learned that they believe most incidental sea lion captures occur between December-March. Determining a technique to reduce the incidental capture of sea lions in gillnets would benefit the fishermen by reducing damage to fishing gear and time spent disentangling the sea lions. Additionally, results that demonstrate luminescent nets reduce sea lion interactions with fishing gear could increase fishermen interest in using the nets in the fishery.

METHODS

To test the affects of luminescent materials on sea turtle bycatch reduction, we will conduct controlled, paired experiments to compare sea turtle catch rates with and without illumination in Punta Abreojos, where green sea turtles occur in high numbers. We'll compare catch rates on an experimental net made of the luminescent material with catch rates on a control net made of non-luminescent material.

To test the affects of luminescent materials on catch rates and market value, we will conduct controlled, paired experiments to compare target catch rates and corresponding market value with and without illumination. We'll compare catch rates and corresponding market value on an experimental net made of the luminescent material with catch rates and value on a control net made of non-luminescent material. These experiments will be conducted in Bahía de los Angeles within an existing small-scale commercial gill net fishery.

In addition, we will conduct oral surveys and a focus group with fishermen participants and other fishermen from the commercial gillnet fishery to determine perceptions of the illuminated nets as a potential bycatch reduction strategy. The answers to our survey will help determine if using the luminescent materials can be a practical, cost-effective strategy to adopt into the fishery. We will also use these surveys to assess the scope of the bycatch problem.

APPLICATION

If using luminescent materials in the nets is shown to be a successful method to reduce sea turtle bycatch and maintain target catch, it may be applied to commercial gillnet fisheries worldwide. In addition, it may provide strategies to reduce sea turtle bycatch in other fisheries (such as longlines or pound nets), reduce interactions with sea turtles and other potential threats (such as power plant intake pipes), and reduce the bycatch of other species (such as sea lions and porpoises).

Sea Turtles

I. State the Research Problem

A. What is the main question (MQ) you are asking?

MQ: What is the effectiveness of illuminating nets with luminescent material to reduce sea turtle bycatch?

B. Why is this question important?

a. Commercial fisheries are economically important industries; however, fishing practices have significant negative impacts.
    i. Supporting discussion points:
        1. Marine species contribute an estimated 15-20% of all animal proteins to the diets of people worldwide.
        2. In 1996, an estimated 30 million people were deriving an income from fisheries worldwide, 95% of them from developing countries.

3. Fishing techniques (long-lines, trawls, gillnets) create problems for the marine environment, including overfishing, ghost nets, and bycatch.

b. Bycatch is a problem for fishermen and marine life.
   i. Supporting discussion points:
      1. Worldwide, an estimated 38.5 million tons are discarded annually, the equivalent of 40 percent of the reported annual production from marine capture fisheries.
      2. Approximately 400,000 turtles are accidentally caught on longlines each year and recent evidence has shown that small-scale gillnet fisheries potentially produce an even greater amount of sea turtle bycatch.
      3. Conservation laws close fisheries when bycatch is high, which means fisheries lose revenue.
      4. Fishermen lose revenue and waste time dealing with bycatch.

c. Bycatch threatens sea turtle populations.
   i. Supporting discussion points:
      1. Possible extinction of species.
      2. Removing sea turtles affects ecosystem/food chain.

d. Gear modification techniques can reduce sea turtle bycatch.
   i. Supporting discussion points:
      1. Mechanical fixes such as TEDs and circle hooks
      2. Behavioral fixes such as visual deterrents

e. Successful methods to reduce bycatch must retain catch of target species, must be relatively efficient, and must maintain market earnings.
   i. Supporting discussion points:
      1. What are some things to think about to achieve these? For example, methods need to be relatively inexpensive, easy to use, etc.

C. What sub-questions (SQ) will you need to address in order to answer the main question?

SQ1: *What are the effects of illumination on sea turtle catch rates?*
SQ2: *What are the effects of illumination on catch rates and market value?*
SQ3: *What are the fishermen perceptions of viability?*

Focus – Testing the effectiveness of illuminating nets with luminescent material to reduce sea turtle bycatch in fisheries

II. SQ1: What are the effects of illumination on sea turtle catch rates?

A. What is already known?

a. Sea turtles are very sensitive to certain wavelengths of light and other visual cues.
b. Recent studies indicate that lightsticks and LEDs influence turtle orientation and swim behavior.

c. Field trials in 2008 showed a decrease in sea turtle CPUE by 40% ($p<0.05$) when LEDs were present on monitoring nets. In 2009, field trials showed a decrease of 59% ($p<0.05$) when lightsticks were present.

B. State your Null Hypothesis (H_o) and Alternative Hypothesis (H_a): What results do you expect to find based on the information you already know?

a. H_o: Illumination will have no effect on sea turtle catch per unit effort (CPUE).
b. H_a: Illumination will either increase or decrease sea turtle CPUE.

C. Methods and Materials

a. Methods
   i. This study will be conducted in Estero Coyote near Punta Abreojos, Baja California Sur, Mexico.
   ii. Two monofilament nets (6m depth, 100m length) will be set.
   iii. Nets will be set near each other in areas with similar depth, bottom topography, and habitat. GPS location of each end of the nets will be recorded to ensure placement in the same location throughout. Environmental data will be taken at each net location including visibility, temperature and depth.
   iv. The experimental net will include the luminescent buoys, float line, and lead line, while the control net will not have luminescent materials.
   v. Nets will be set for ~12 hour periods and set for 3 consecutive nights during neap tides.
   vi. Nets will be checked at a minimum of every hour and a half throughout the night by trained local fishermen, scientists, and students. Number of turtles will counted for each net.
   vii. Morphometric data will be collected for all captured turtles and the turtles will be flipper tagged and released.

b. Materials
   i. GPS (Global Positioning System)
   ii. Secchi disk
   iii. Depth finder
   iv. Digital thermometer
   v. Flipper tags
   vi. Tag applicator
   vii. Zip ties
   viii. Wire cutters
   ix. Calipers (2)
   x. Measuring tape
   xi. Clipboards
   xii. Pens
   xiii. Datasheets printed on write in the rain paper
   xiv. Camera
   xv. Headlamps
   xvi. Spotlight
   xvii. Batteries
   xviii. All safety equipment (radio, 1st Aid Kit, water, etc.)

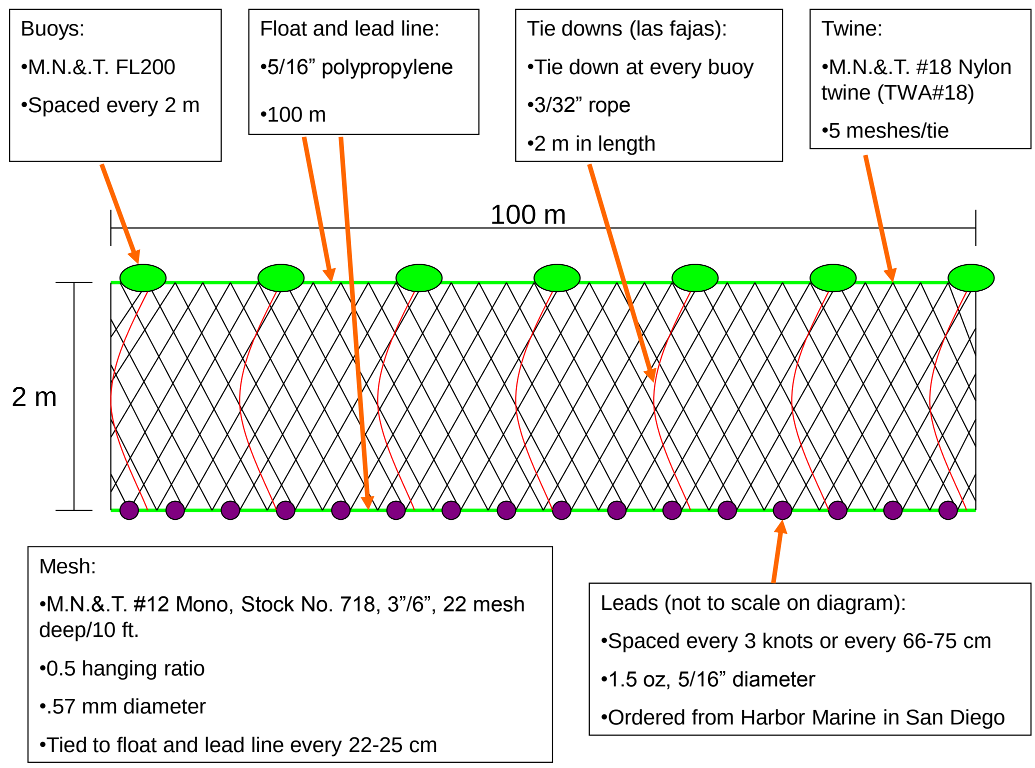


Figure 5: Diagram of experimental net made of luminescent materials for use in Punta Abreojos. Luminescent materials are highlighted in green.

III. **SQ2: What are the effects of illumination on catch rates and market value?**

A. What is already known?

a. Fishermen report that CPUE in gillnets is reduced during a full moon.

b. Field trials in 2008 and 2009 showed LEDS increased target catch CPUE by 2% and catch value by 16%. Lightsticks increased target catch CPUE by 2% and did not significantly affect catch value.

B. State your Null Hypothesis (Ho) and Alternative Hypothesis (Ha): What results do you expect to find based on the information you already know?

a. H_o: Ilumination will have no effect on catch per unit effort (CPUE) of target species, bycatch species or other species.

b. H_a: Illumination will either increase or decrease CPUE of target species, bycatch species or other species.

C. Methods and Materials – Catch Rates:

a. Methods

i. This study will be conducted in Bahía de los Angeles, Baja California, Mexico in existing small-scale, gillnet fisheries that target guitarfish, rays, and California halibut.

ii. Two pairs of nets, approximately 250m length each, 1.5m height (slightly pursed) 6.5-8 cm. mesh, will be set near each other in areas with similar depth, bottom topography, and habitat. Sites will be marked by GPS.

iii. Environmental data (depth, tides, moon phase, temperature, and visibility) will be recorded.
iv. The fishermen (and their nets) will be randomized for each set location (Site 1 –north/east, south/west or 2 – north/east, south/west) and type of set (experimental or control).
v. The experimental nets will include the luminescent buoys, float line, and lead line. The control nets will not be made of the luminescent materials.
vi. Nets will be set for a period of approximately 12 hours during dark hours.
vii. Nets will be set 3 nights per week for 3 weeks.
viii. Nets will be pulled first from the same end where it was set first.
ix. The number, species, and category (target species, bycatch species and other species) of the total catch will be recorded along with fish length.

b. Materials
i. GPS (Global Positioning System)
ii. Secchi disk
iii. Depth finder
iv. Digital thermometer
v. Zip ties
vi. Wire cutters
vii. Flagging tape
viii. Calipers (2)
ix. Measuring tape
x. Fish handling gloves
xi. Labeled fish crates
xii. Boots
xiii. Aprons
xiv. Clipboards
xv. Pens
xvi. Catch datasheets printed on write in the rain paper
xvii. Fish ID Guides
xviii. Camera
xix. Headlamps
xx. Spotlight
xxi. Batteries
xxii. All safety equipment (radio, EPIRB, 1st Aid Kit, water, etc.)

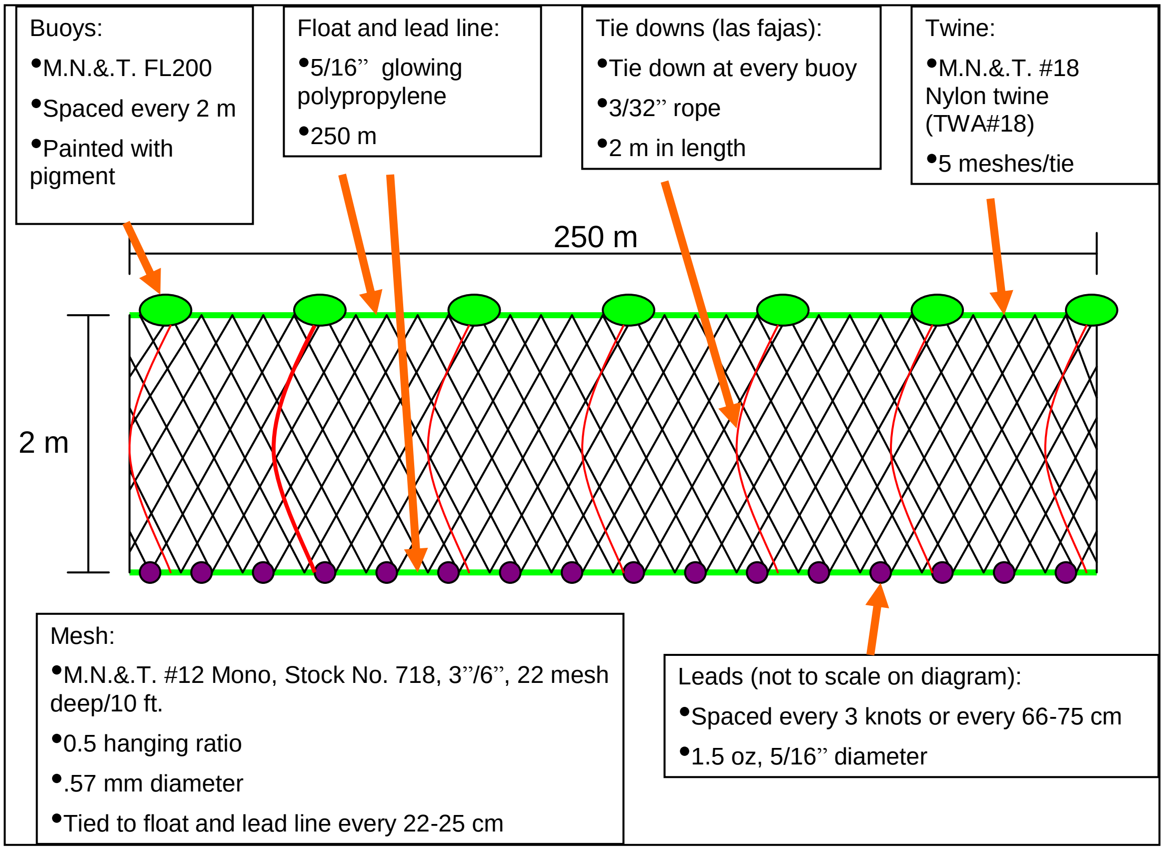


Figure 6: Diagram of experimental net made of luminescent materials for use in Bahía de los Angeles. Luminescent materials are highlighted in green.

D. Methods and Materials – Market Value

a. Methods

i. This study will be conducted in Bahía de los Angeles, Baja California, Mexico in existing small-scale, gillnet fisheries that target guitarfish, rays, and California halibut.

ii. Two pairs of nets, approximately 250m length each, 1.5m height (slightly pursed) 6.5-8 cm. mesh, will be set near each other in areas with similar depth, bottom topography, and habitat. Sites will be marked by GPS.

iii. Environmental data (depth, tides, moon phase, temperature, and visibility) will be recorded.

iv. The fishermen (and their nets) will be randomized for each set location (Site 1 –north/east, south/west or 2 – north/east, south/west) and type of set (experimental or control).

v. The experimental nets will include the luminescent buoys, float line, and lead line. The control nets will not be made of the luminescent materials.

vi. Nets will be set for a period of approximately 12 hours during dark hours.

vii. Nets will be set 3 nights per week for 3 weeks.

viii. Nets will be pulled first from the same end where it was set first.

ix. The number, species, and category (target species, bycatch species and other species) of the total catch will be recorded along with fish length.

x. The catch will be cleaned after each net is pulled and fish will be brought to the field station.
xi. Fish will be weighed and market value will be recorded based on the weight of fish and price per kilo.

IV. **SQ3 – What are the fishermen perceptions of viability?**

A. What is already known?

a. Some bycatch species are entangled in fishing gear while trying to predate on the catch or bait.
b. Removing bycatch from fishing equipment can increase effort (e.g. time spent disentangling a sea turtle from a gillnet).
c. Gear modifications can increase fishing effort.
d. Field trials in 2008 and 2009 indicate no significant difference in market value of target species between control and illuminated nets.

B. State your Null Hypothesis (Ho) and Alternative Hypothesis (Ha): What results do you expect to find based on the information you already know?

a. H_o: Illumination as a sea turtle bycatch reduction technique is not likely to be adopted in nighttime small-scale, commercial gillnet fisheries.
b. H_a: Illumination as a sea turtle bycatch reduction technique is likely to be adopted in nighttime small-scale, commercial gillnet fisheries.

C. Methods and Materials: Fishermen perceptions of viability

a. Methods II: Fishermen perceptions of viability
    i. This study will be conducted in Bahía de los Angeles, Baja California, Mexico with fishermen working in existing small-scale, gillnet fisheries.
    ii. A survey will be developed to ascertain fishermen’s perceptions of net illumination as a practical, cost-effective gear modification technique to reduce sea turtle bycatch.
    iii. The survey will be administered orally after their participation in the study testing the effect of net illumination on capture rates in the gillnet fishery.
    iv. The survey will be administered by trained staff and student researchers.
    v. A focus group will be held with the fishermen after completing the survey to further discuss their responses. Preliminary results of the research will be shared with the fishermen after the survey, prior to the focus group.
b. Materials II – Fishermen perceptions of viability
    i. Surveys
    ii. Pens
    iii. Clipboards
    iv. Voice recorder
    v. Video
    vi. Dry erase board

Note: If there are clear trends demonstrating that any portion of the experimental designs are increasing the amount of bycatch, the researchers will alter the methods or halt field work.

Attachments

See Attachments: DR Calendar, DR Concept Map, Fishermen Survey, Fisheries Table PA, PA Net Diagram, Fisheries Table BLA, BLA Net Diagram

Logistics

Boats & Guides

- 4 pangas with 4 fishermen (mornings): Francisco "Pancho" Verdugo Leree, Roberto Ocaña Fuerte, Basilio Navarro Verdugo, and Hector Morales Romero.
- 4 pangas with 8 fishermen (evenings): Francisco "Pancho" Verdugo Leree, Roberto Ocaña Fuerte, Basilio Navarro Verdugo, Hector Morales Romero, Hector Morales Arce, Efren Ocaña Fuerte, Efrain "Cury" Cordero Rubio, and Eric Navarro Verdugo

Coordination with Monitoring

- In PA, let Grupo Tortuguero know when we will be there so they can conduct turtle monitoring on the other neap tide.
- In BLA and PA, when possible we will take morphometrics and give to GT and Jeff Seminoff.

Detailed Bahía Pesca Research Methods 2010

A. Ocean Discovery Institute participants will join fishermen at the beach near the research station and ride in the boat to the location where the net will be/has been set.
   a. All fishermen should meet each morning at the beach (pick-up location). At this time, previous night's datasheets should be collected and updates given to the group as a whole. Paired boats should always depart and arrive together.
      i. Nights
      6:45pm depart from beach/station
      7:00pm set nets
      8:00pm return to beach/station

      ii. Mornings
      5:10am wake up (Pesca cots to be located closest to cot put-away area)
      5:30am depart from beach/station
      5:45am pull and check net
      8:15am leave net location
      8:30am Eat breakfast, debrief and go over data sheets
      9:00am rest (siesta activities – resting, reading, writing)
      10:30am Put away/Prep & Data Entry (1/2 group) and Weigh Station (1/2 group)
      11:00am weigh fish and calculate market value, put fish in fridge for China
      12:15pm done

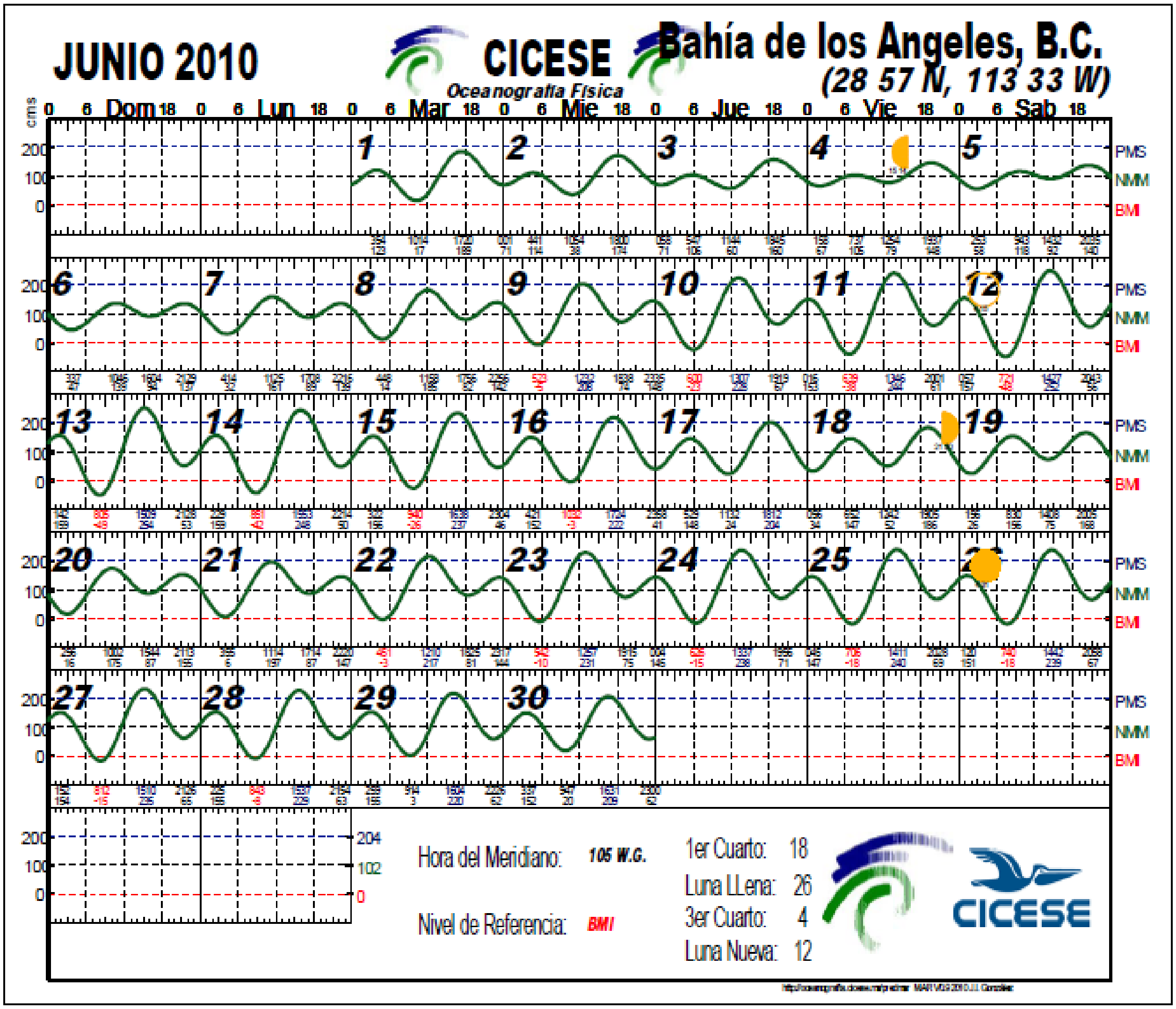
B. Net setting and location: two pairs will be set each day, with 4 boats and fishermen (4 fishermen when ODI present, 8 fishermen when ODI not present). Fishermen may choose to leave the nets in the same location or move locations within the 3 days of setting.

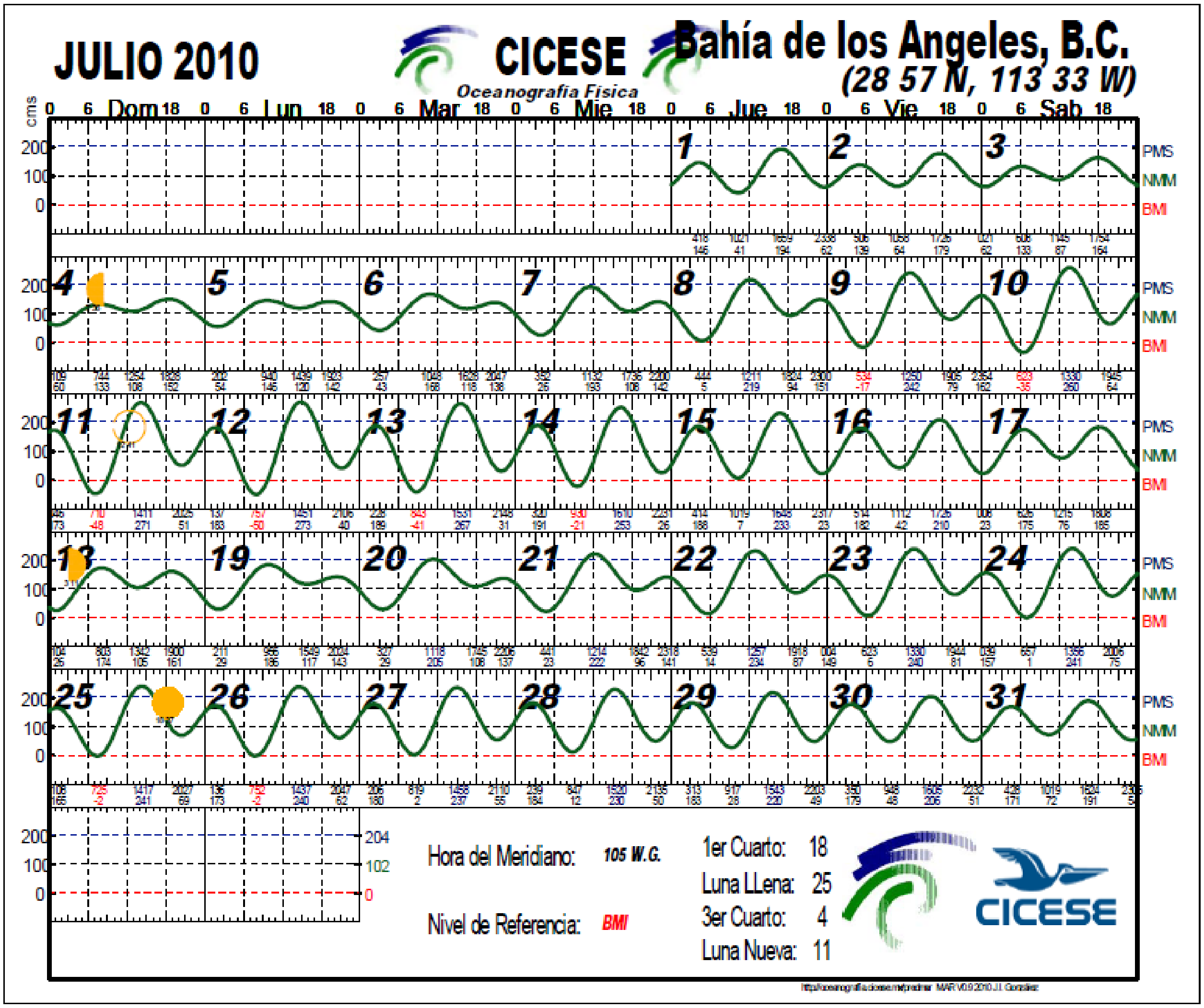
Past locations:

a. Estero Este (east) and Oeste (west), sandy bottom, 50-75’ approximately (17-25m)
    i. On either side of the mouth of the Estero, not directly in front of the mouth
b. La Mona Este and Oeste, Sandy bottom, 35-50’ approximately, (12-18m)
c. La Gringa Norte and Sur, Sandy bottom with seaweed, ~40-50’
d. Salomon Norte and Sur, Sandy bottom with seaweed, ~30-40’
e. Campo Payaso/Soldados Norte and Sur, Sandy bottom with rocks and grass
f. Ramon Verdugo/Campo Archelon Norte and Sur, Sandy bottom with rocks and grass
g. Each pair should be approximately 100m apart. Replicate pairs should be further apart.

C. Environmental data (depth, tides, moon phase, temperature, and visibility) will be recorded. The tide is calculated as the change between the tide at the beginning of the net set and at the beginning of the net pull (approximately the same for all 4 nets).
    i. The fishermen (and their nets) will be randomized for each set location (Site 1 –north/east, south/west or 2 – north/east, south/west) and type of set (experimental or control).
D. The end of the net that was set first should be the end of the net that is pulled first (to allow for the same amount of soak time).
E. Datasheets should be collected and checked for errors <u>every day</u>.
F. The catch will be cleaned by the fishermen each morning.
    a. At the station (week 1) and at their places following.
G. The fish will be brought to the station at 11am and fish will be weighed and market value will be recorded.
    a. Each boat and each set (day, night) will be kept separate.
H. A meeting should be held with all fishermen once a week to review methods, address
I. issues, questions, etc.

Tide Calendars 2010





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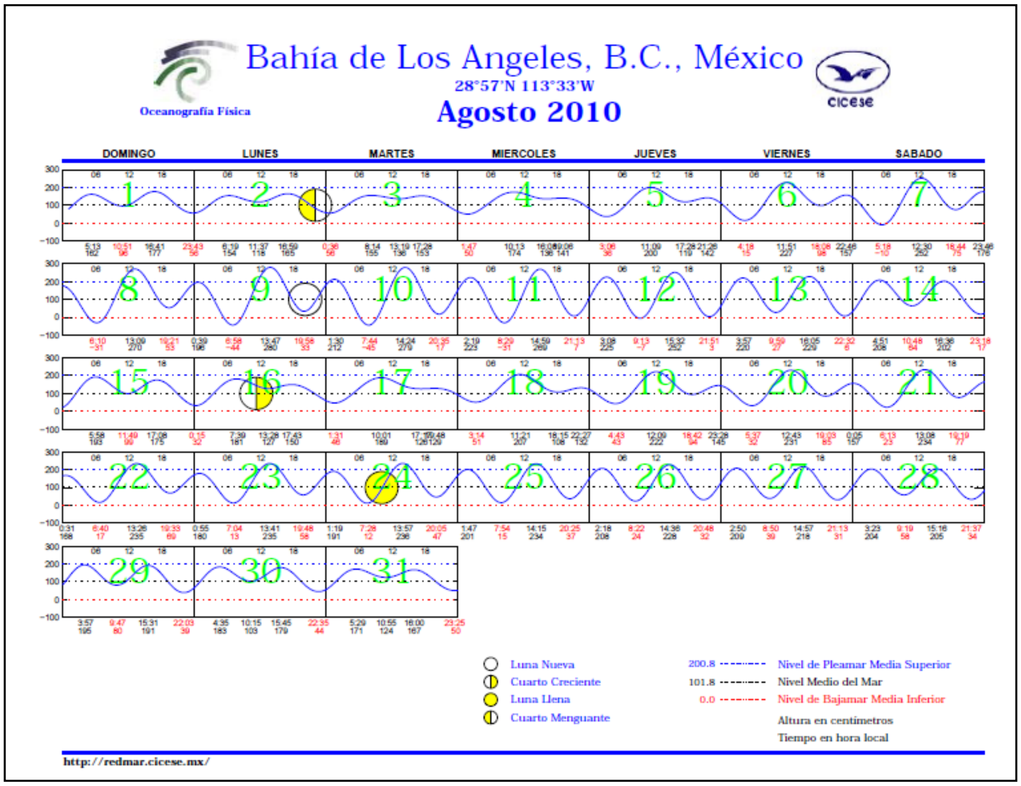
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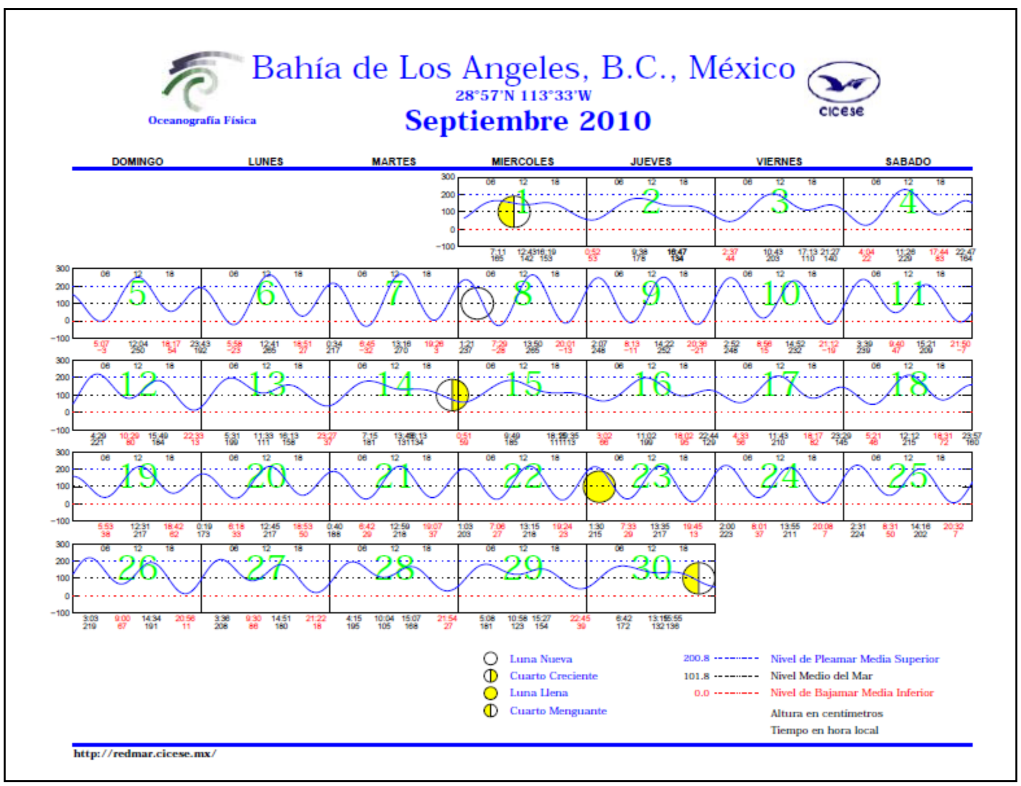
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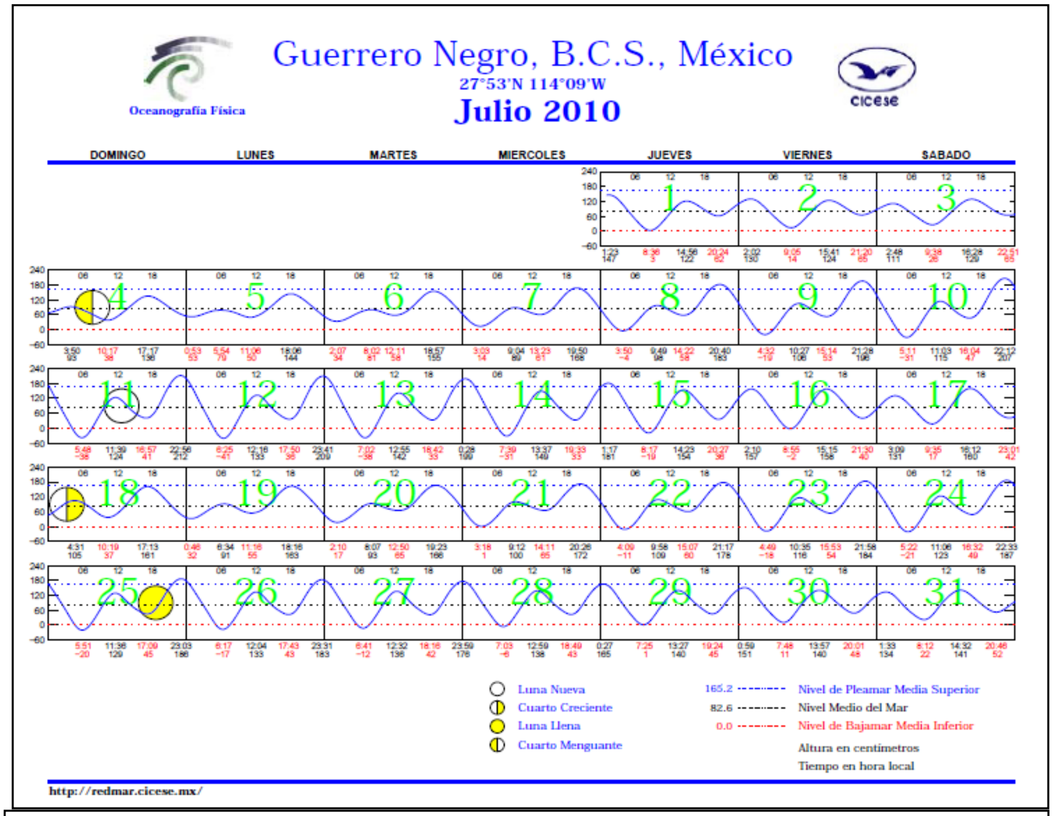

Oceanografía Física
Guerrero Negro, B.C.S., México
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Tiempo en hora local
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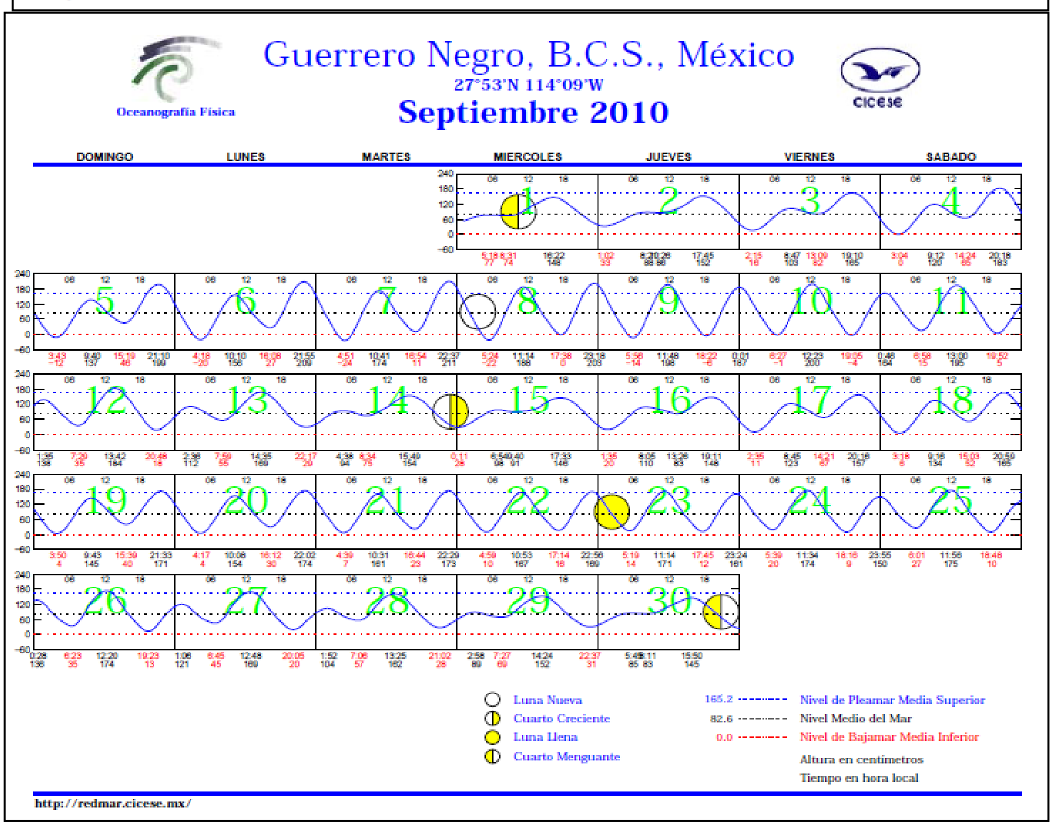

Oceanografía Física
Guerrero Negro, B.C.S., México
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http://redmar.cicese.mx/

Background Info

Budget

- BLA (quoted 4/18/10): $130 in morning with helper; $100 in evening with no helper – we will keep the fish to eat
  - 1 boat= $230/day, 4 boats = $920/day
  - $2760/week (3 days x $920)
  - $2760 x 3 weeks= $8280
- PA: $80/boat + $70/person
  - Need 2 boats just to get out there, $80x2= $160/night
  - $70/person x 2 people=$140/night = $300 total/night
  - 3 nights X $300 = $900

Fishermen in Bahía de los Angeles

Fishermen who are consistent in commercial fishery using gillnets:

- Oscar Sabin Smith (nickname is Juero, wife is principal of elementary school)
- Julio Moreno (he is the principal of the high school)
  - Several guys work with Julio – Alonso
- Alejandro Arce (nickname is Cando, wife is Juanita and works at Las Hamacas)
- Roberto Ocaña
- Basilio Navarro
- Fishermen who do commercial work:
  - Ramon, Pancho Verdugo, Diego, Carlos Verdugo
  - Jesus Fuerte (lives in green house behind elementary school)
  - Erik Arroyo
  - Hector and Francisco Aguiles
  - Victor Ignacio Lizarra Sanchez (Maria Jesus, wife)
  - Hector Morales
  - Chemin and Fermin Smith
  - Chema
  - Mango
  - Yoshio Jr. and Yoshio
- Total there are 20-30 teams of fishermen and roughly 15 pangas.
- Buyers are Victor Ignacio Lizarra Sanchez (and his wife Maria Jesus) and Julio Moreno
- There is an association for commercial fishermen. Not all fishermen are members. One reason to join is that they help to get permits.

Fisheries in Bahía de los Angeles

- Fishing is best:
  - When not full moon (fish can see the net when the moon is full/bright)
  - During the night
  - When tide is coming in
- Time it takes to pull:
  - Encerrando - takes about 40 minutes from spotting fish to hauling in

  - Gill nets – approximately 400m net takes 1-3 hours, 200m net takes ½ to 1 hour
- Infrastructure:
  - Lack of ice in summer makes it so that they can't fish. Some people say summer generally. Oscar says only August.
  - Ice comes from Ensenada in a truck. The buyers bring it.
- Sport fishing is mainly March-August.
- Permits:
  - Permits are needed by species. Gear and methods are specified on permit.
  - Can have permits that last 1-4 years.
  - Cost of permit is approximately 1,500 pesos/year ($150).
  - Permits are divided in groups:
    - Escama ("fish with scales"): Cabrillo, Jurel, Linguado, Vieja, Blanca, Sardinero, Garopa, Burrito, Mojarra, etc.
    - Tiburón: Mantas, Guitarra, Angelitos, etc.
    - Lisa
- Catch:
  - Very rough estimate of guitarfish, ray, etc. fishery: Daytime maybe 20-30 animals, Nighttime maybe 75
  - Shark fishery used to be much stronger. 10 years ago, Ricardo was a shark fisherman. He fished 3 years with nets catching more than 100 sharks a night and then the fishery collapsed.
- Market:
  - There are two buyers in town who have a truck with ice (Julio and Victor Ignacio). They buy the fish from fishermen and take and sell in Ensenada, Tijuana and Mexicali. Those fish plants sell to US, Mexico and Japan.
  - Fishermen only eviscerate fish and give to buyers. Guitarra the heads are cut off and they are bought. Rays' fins are cut and sold. Cleaning of fish takes about 1 hour after fishing.
  - See excel sheet for market prices.
- Bycatch:
  - In gill nets fishing halibut, rays, guitarfish, etc:
    - Approximately 1 sea lion/24 hours in approximately three 400m nets.
    - Dolphin is occasional bycatch.
    - Birds and turtles are caught more often when nets are closer to the shore (summer).
  - No bycatch reporting requirements

Appendix C: Fisherman Survey

Pesca Fishermen Survey 2010
The purpose of this survey is to learn more about fishermen perspective on bycatch and illumination as a reduction strategy. For the context of this survey: All questions about fishing refer specifically to fishing with bottom-set gillnets and questions regarding bycatch refer to the unwanted capture of sea lions, sea turtles, and birds in these nets.

Name:

Ocean Discovery Institute fisheries research participant: Y/N

1) Is bycatch a problem for you?

   Y/N

2) If yes, rate how much of a problem the following bycatch issues are for your fishery:

	1 (not important) to 5 (very important)				
1. Time spent removing the bycatch	1	2	3	4	5
2. Damage to nets	1	2	3	4	5
3. Loss of target catch	1	2	3	4	5
4. Other: if other, what?	1	2	3	4	5

   ____

3) Which of these animals do your fishery catch the most frequently?

   1. Sea lions
   2. Sea turtles
   3. Birds

4) What month do your fishery most commonly catch sea lions?

5) What month do your fishery most commonly catch sea turtles?

6) What month do your fishery most commonly catch birds?

7) Do you think whale sharks are ever caught in nets? When and where?

In the past, we have tested attaching lights to nets. We found that LED lights reduced sea turtle bycatch by 40%, while lightsticks reduced sea turtle bycatch by 60%. Neither light source changed the amount of target catch rates or market value. This year, we used nets pre-made out of luminescent materials, which ____________. (to be filled in with results from 2010)

A) Would you use lights in your nets? Y/N

   a. Why or why not?

B) Would you use luminescent nets? Y/N

   a. Why or why not?

C) Which do you think is better? Why?

D) If you're willing to use this gear, how much would you spend per 600m net?

E) Rate the following factors as to how important they would be in using a new gear type:

	1 (not important) to 5 (very important)				
Gear easily available to purchase:	1	2	3	4	5
Free gear:	1	2	3	4	5
Strict regulations/enforcement:	1	2	3	4	5
Reduces sea lion catch:	1	2	3	4	5

F) What other solutions or suggestions can you think of to decrease bycatch?