SAN DIEGO BAY

A Call for Conservation

by the students of

Gary and Jerri-Ann Jacobs High Tech High

Foreword by E.O. Wilson

Preface by Jane Goodall

Predator-prey along an urban bay by Kelsey Hoffman, winner of the Kurt Vavra Nature Photo Contest, 2007.

Preface

the Jane Goodall Institute

One of the problems with education in so many countries is a lack of freedom for teachers to design learning experiences that they know will benefit their students. High Tech High is unusual. Teachers are not only permitted but encouraged to think out of the box and they, in turn, involve their students in choosing, planning and executing projects that will enhance their learning experience.

We are at a crossroads—we humans have inflicted grievous harm on our environment bringing species to the brink of extinction, and entire ecosystems to the point of collapse. It is the youth of today that will suffer if, together, we cannot work to heal some of the damage: surely they deserve the opportunity to have a say in how this should be done? The students taking part in the projects described in *San Diego Bay: A Call for Conservation* are the scientists, engineers and policymakers of the future. And, too, they are the next generation of teachers and parents.

I have admired the farsighted policies of High Tech High ever since I met Jay Vavra. He introduced his students to our Roots & Shoots program: we share the similar goal of teaching youth about the problems we face and empowering them to take action to address those problems, to make choices that will make the world a better place.

Only recently has the importance of preserving biodiversity received the attention it deserves from politicians and the general public. And even when people do know, only too often they do little or nothing to help make a difference. Thus it is immensely gratifying to see that the students who have researched, written and designed this beautiful book address this threat, along with other problems such as pollution, development, invasive species and climate change.

One of the key elements in our Roots & Shoots program is to encourage members to pay special attention to *local* problems. Young people who study the ecology in their own "backyards," learn to understand and appreciate it. The High Tech High students have taken steps to ensure that their environment is preserved for the benefit and enjoyment of future generations. Moreover, they have learned the importance of acquiring solid facts before speaking out against actions that have harmed or are harming their environment: they are then able to articulate and explain their concerns and this approach can then lead to changes in the way people think and, sometimes, to changes in their behavior.

These students have become experts in their respective fields. They have learned the facts through their own research, rather than accepting all that they hear. It is firsthand information they share here. They are convincing and this book provides policymakers with pertinent facts that can be used to evaluate, for example, the current status of local endangered species, the factors that contribute to these threats, and clear suggestions about how these should be tackled.

I know full well the amount of work and dedication that has been necessary to carry out the diverse range of original research presented by these students. Their investigations have included population surveys, behavioral observation, and the recovery and release of light-footed clapper rails, to the sophisticated molecular biology of DNA barcoding. Collectively their work comprises a scientifically meticulous and incredibly sophisticated study.

Most people are amazed that such important results can be achieved by high school students. I am not one of those! I know this group of students—the "High Tech High Roots & Shoots" team—and have become familiar with their high standard of excellence. Each year they design innovative ways of working within their communities to improve the lives not only of wildlife but also the human population of San Diego.

One of my reasons for hope is the growing number of young people who care about the future of Planet Earth. These students exemplify the kind of informed, passionate, determined and active young people who can, together, create a more harmonious future, which is immensely reassuring since they are the future stewards.

Jane Goodall Ph.D., DBE
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Teacher Introduction

Our concern for the environment has grown over the years. As teachers in biology, humanities and mathematics, we have found, together with our students, a gradual deterioration in our natural surroundings. The study of our local environment, San Diego Bay, has told us that the environment left to us today is nothing like that originally witnessed by the bay's early humans. We know, with our student authors, that we have inherited an environment much diminished in diversity and sustainability.

From previous generations our students have acquired a disease not of their making. Those coming of age today face a planet made sick by climate change, species extinction, human population growth and shortsighted human interaction with the environment.

And, we find these changes have occurred largely unnoticed. Using biology's concept of a "shifting baseline," we know that this much-diminished landscape, a long time in the making, will only continue its decline if we fail to first recognize the problem and take steps to address it.

This book is the fourth in a series written and produced by our students. Through the books, we hoped to empower our students with meaningful work and help provide them with a greater appreciation for nature. *San Diego Bay: A Call for Conservation,* examines the bay's current state of health, discusses reasons for its decline, and provides positive solutions. It is our hope it will inform, alert and help other concerned individuals and communities with their own conservation and restoration efforts.

In the following pages, student authors express their findings and concern through original research and original commentary. The chapters address their topics through a review of literature, fieldwork, DNA barcoding, the taxonomy of organisms and interviews with local experts. Original poetry, nature reflections and photography provide insight, commentary and student perspective. While, as teachers, we planned the book's chapter headings and general outline as much as possible, along with the topics to be covered and research to be done, our year together also took its own twists and turns.

Some of our story unfolded before us and made teachable moments that could not have been scripted. The killdeer nesting in the school parking lot over spring break showed us with heartbreaking relevance what the loss of habitat means to precious killdeer chicks. We learned first hand that we can help distraught wildlife. Upon further reflection, we found, even in this misplaced nest, a message of hope; when creatures adapt to hostile environments, they are reclaiming part of what was lost.

In another unscripted event, attending Brent Stewart's talk on the now extinct Baiji Yangtze River dolphin was both poignant and prescient. His tragic tale revealed the universal warning in much of this book, should we choose to listen. We cannot recover an extinct species, just as the bay's environment may not recover from thoughtless land use, ship traffic and pollution. Together, with our students, we have come to the conclusion that if we ignore our environment's baseline, diversity or natural refuges, we do so at our own peril.

While much of contemporary society focuses upon the role of the individual, we found hope in the work of gifted individuals and in collective efforts. In their final chapters, our students considered the far-reaching work of Carl Hubbs, San Diego's own great marine biologist, and the many different collective agencies known as the Stewards of the Bay. Our authors found in these local agencies and nonprofit organizations a collective effort and common mission to help heal the bay. As part of our own contributions, we formed new alliances with local environmental concerns and agencies. Bringing together research partners at the San Diego Zoological Society and innovative products and support of the biotech industry from Invitrogen Corporation, students were able to apply novel molecular tools to describe important components of this conservation story.

Edward O. Wilson has diagnosed all of us with a case of Biophilia. In this positive conclusion, Wilson sees each of us with an innate sense of affection for life. Has humanity somehow made itself immune from this wonderful condition? We answer "no." Though, at times, we act as if we are separate or apart from our natural surroundings, we find hope in Wilson's belief that we have a compassion for nature.

Our students arrived in class with a feeling of disconnection from their natural world. By addressing this, the authors rekindled their primal connection and renewed a compassion for life and the environment. In order to conduct the study, complete the research and finish the writing, the truth of our integral place in nature reemerged. The project itself shows the spirit of these students and those community experts who assisted in their explorations. Through fieldtrips, class seminars, naturalist literature, DNA technology, statistics, labs and work in natural history, we concluded that a simple shift in consciousness will allow us to see we are inextricably part of one earth, one environment. As such, we find ourselves called to conservation.

Jay Vavra, biology teacher
Tom Fehrenbacher, humanities teacher

Gary and Jerri-Ann Jacobs High Tech High

Student Introduction

It is hard to believe that in less than six years, students from High Tech High have produced and published three books detailing the beauty and history of San Diego Bay. *Two Sides of the Boat Channel*, *Perspectives* and *San Diego Bay: A Story of Exploitation and Restoration* are the publicly acclaimed precursors to this story, which now looks into the unique history of conservation in the San Diego Bay area. *San Diego Bay: A Call for Conservation* is an extensive analysis of the delicate balance between humans and nature in an urbanized ecosystem. Through this analysis, we attempt to promote a need for conservation in this diverse ecosystem we all call home.

In our studies, we discovered that San Diego is home to an array of unique species, due mostly to the wide range of habitat the bay has to offer. This delicate biodiversity, as acclaimed biologist and author of this book's foreword Dr. E. O. Wilson emphasizes, is the key to a rich ecosystem. We attempt to demonstrate the incredible amount of diversity that exists in our own backyards.

Additionally, the land in San Diego also creates a diversity of ecosystems. The wetlands that surround and weave through the city limits are home to many wildlife species. With the incredible conservation efforts of local organizations, these wetlands serve as a prime story of a constant battle for restoration and conservation. They are the habitats that we must fight to protect in order to save the homes of these species.

As we observe the change in these ecosystems over time, we realize our dependence on "perspectives" to determine whether or not the habitats are truly natural. This dependence on perspective to define "nature" is represented in an ecological buzz phrase called shifting baselines, a concept heavily studied by professors at the University of California in San Diego. Through this concept, we hope to portray the flux of nature and our innate inability to fully understand what is truly natural in the bay.

These themes are kept throughout the book as we began to understand the threatened species of the bay. The book includes a short section on methods used to study and assess information for our story. We then focus our attention on the species, mostly avian, which are threatened by human activity. An outline of each organism's biology is given at the start of their section. Students wanted to focus on the unique living habits, dietary patterns, and morphological features that were unique to these species. Then, each species is analyzed for the cause of its loss from the bay. From pesticide to habitat destruction, the next section attempts to pinpoint the causative agents, which have led to population decline.

Finally, the recovery section attempts to highlight the successful efforts, to bring these beloved organisms back, often from the brink of extinction. Unfortunately, these species are often only afforded the protection that our society's resources allow. We hope to demonstrate the need for continual effort in conserving the unique species that make up our bay, and, equally importantly, preserving their habitats. The species were chosen for their degree of imperilment or lack of recognition in terms of conservation efforts. Our list of species represents only a small portion of those affected, both positively and negatively, by man's presence in San Diego.

In the next section of our story, we pay close attention to the activities and ecological events that have directly or indirectly contributed to the need for conservation. As one of the of the major bays on the West Coast, San Diego Bay has a heavy amount of traffic from commercial, military and recreational vessels, often traveling to and from foreign waters. Student researchers highlight the pollution, exploitation and environmentally unhealthy urban growth in San Diego. Another unnatural cause of stress on the environment comes from the invasive species introduced by maritime activity. Invasives such as the Asian mussel or a type of tunicate threaten San Diego Bay by throwing the delicate ecosystem off balance. This section highlights those and other creatures that are having a detrimental effect on the bay's endemic species.

Yet one of the largest human impacts on the bay has been the coastal development and reconstruction that has occurred in this beach city. The effects of dredging as well as increasing land use have destroyed crucial habitats and pushed creatures to the test. Together, these pieces highlight the constant battle of man versus nature in the form of land development. Yet one of the most widespread and unavoidable effects has sprung from the global changes in our climate. Thus, our final topic of the section focuses on the effects of climate change worldwide and how that relates locally to San Diego.

In spite of the list of causes for decline in species around San Diego, this city is also an incredible resource for restoration and conservation efforts. The final section of the book deals with the fight for the survival of species locally and globally. The first solution focuses on the national Endangered Species Act and how that has affected local efforts through raised awareness, federal protection of species, and increased regulation enforcement. In addition to national effort, there are local stewards of our bay, the individuals and organizations that donate time and effort to the survival and sustainability of our diverse ecosystem, its endangered creatures and habitats. We thank our stewards for keeping the message of conservation and hope alive in San Diego restoration efforts. One specific effort of interest is the eelgrass restoration project in San Diego's coastal waters. We felt this to be a staple story of detriment that led to concern that led to action. Eelgrass restoration shows how our

efforts can truly make a difference. Another effort focuses on the sustainable fishing practices, a global concept adopted in San Diego. Sustainable fisheries strive to practice environmentally friendly methods to manage their catches, as well as promote a solution to overfishing. The concept demonstrates how communities can work together to save species while still maintaining effective levels of production. The land itself has proved to be a ground for great strides in protection. Yet San Diego is unique in its coastal extension to the heavily trafficked seas and we focus on the marine protected areas that protect our beautiful oceans.

Finally, we focus on the individuals who greatly contributed to local restoration efforts. One man in particular, Carl Leavitt Hubbs, is notable by expanding our knowledge of the natural world and changing the way we view the environment. We hope to commemorate his efforts by demonstrating just how much of an impact Carl Hubbs, a true student of holistic environmental philosophy had in San Diego.

These organisms, problems and solutions all come together to create an extensive overview of conservation needs in San Diego. We are not only high school students, but students of the school of environmental holism, following in the wake of John Steinbeck and Ed Ricketts, who have taught us the importance of applying connection, complexity and compassion in order to sustain life. Our ongoing studies strive to demonstrate the importance of environmental awareness and action, and to show that individuals can make a profound difference. Thus, our book is not just a story, but rather a call for conservation that we hope will echo across the beautiful city of San Diego and beyond, for the benefit of our biosphere and all its inhabitants.

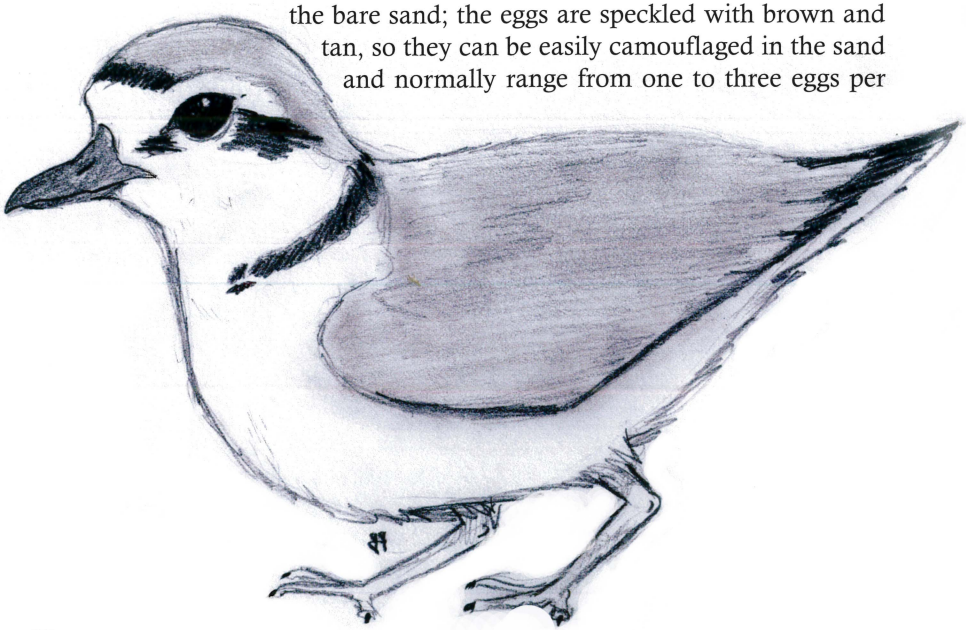
Gary and Jerri-Ann Jacobs High Tech High Student Authors

Western Snowy Plover

(Charadrius alexandrinus nivosus)

The Western snowy plover is one of the most threatened shorebirds in the United States. This petite and rare plover finds no better home than San Diego's famous sandy coastline, which is unfortunately a perfect place for human interference and habitat destruction. The Western snowy plover primarily nests in pairs in coastal regions. It ranges from 15 to 17 centimeters tall and typically weighs 34 to 58 grams. Its coloration consists of a white underbelly, a tan top and black markings on the neck, head and above the beak, allowing it to blend in with its surroundings. The plover lives along the California and Mexican coastlines, but has been sighted as far north as Washington. San Diego currently has the largest concentration of the species in the United States, with 207 plover sightings during the Audubon Society's Christmas Bird Count in 2006. Its diet consists mostly of insects such as brine flies—small flies that are commonly found on beaches around mounds of kelp. However, it will also occasionally feed on small crabs or other invertebrates. ("Snowy Plover" 2007) (Unitt 2004)

Western snowy plover nesting grounds are typically located on sandy beaches and dried mud flats. Like all plovers, it places its eggs on the bare sand; the eggs are speckled with brown and tan, so they can be easily camouflaged in the sand and normally range from one to three eggs per



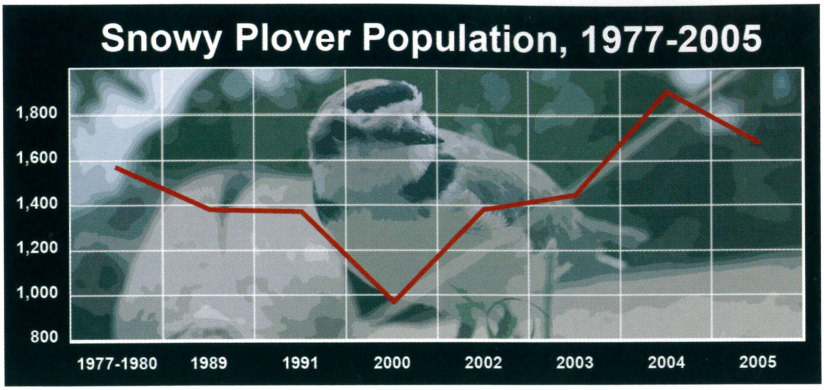
nest. During mating season, the female plover lays her eggs and then leaves the nest-guarding responsibilities to the male. When a nest is approached by a predator, the male bird will act as though it has a broken wing and will then attempt to lead the predator away from the nest. If the predator is not deterred, the plover will flee the nest. This technique has worked in deterring predators for thousands of years, but unfortunately it is not helping the plover to survive human disruptions, and the bird is currently facing grave declines in population. (U.S. Fish and Wildlife Service 2006)

Decline of the Western Snowy Plover

Along with the California least tern, the Western snowy plover has become the poster bird for threatened coastal dunes and sandy beach habitats in California. The portion of the species that nests on coastal beaches and adjacent bays was protected under the Endangered Species Act in 1993. There are many causes for the bird's decline, but the main issue is habitat alteration occurring through development. Every year more and more habitat is being lost to the building of beach-front condos, houses, restaurants, hotels and paved parking lots.

The reproduction rate of the plover has also been affected. Not only have human disturbances, predation and habitat loss affected its nests and current incubations, but the plover has been discouraged from nesting altogether. Another reason is the increased use of beaches in California, via off-road vehicles and beachcombing. The U.S. Fish and Wildlife Service has observed that the nesting season for the plover (March to September) coincides with the most active recreational beach activity. These activities can disturb or even destroy plover nests, but not all of the causes of plover population decline can be directly attributed to humans. Invasive species such as foreign grasses have reduced the amount of available breeding grounds for plovers; and predation by animals such as dogs, cats and red foxes is responsible for the destruction of many nests. ("The Snowy Plover Page" 2007) (U.S. Fish and Wildlife Service 2007)

As for population size, between the years of 1977 to 1980 there were approximately 1,590 Western snowy plovers in California. For the period 1989–1991 the population had dropped to about 1,370 individuals and by 2000 it had further fallen to an alarmingly low number of less than 1,000. After this disastrous decline, the California population thankfully began to increase—in 2002 there were 1,387 recorded observations, followed by 1,444 in 2003, 1,904 in 2004 and 1,680 in 2005. In 1970 plovers nested at more than 50 sites in the state, but today there are fewer than 20 of these sites left. If even one of these nesting sites were to be lost to development, it would be potentially disastrous for the Western snowy plover population in California. (Tijuana River National Estuarine Research Reserve 2007) (U.S. Fish and Wildlife Service 2007)



Day-old snowy plover hatchlings sit on a nest of shells.

Recovery of the Western Snowy Plover

Although this shorebird is threatened, strong activism has kept it from extinction. There are many organizations that have devoted themselves to the recovery of the plover and its fragile habitat. Unfortunately this diminutive plover resides in some of the most sought-after real estate in North America.

From 2000 to 2004, the plover population increased by almost 1,000 from previous numbers, however this declined again in 2005. The majority of the plover population resides in California with nearly 1,700 individuals. Only about 100 individuals were observed in Oregon and Washington combined. (U.S. Fish and Wildlife Service 2007)

This increase is partly due to the establishment of private plover breeding grounds. Many development projects have been halted because they would have been built on plover breeding habitat. The military has also stepped in to assist in the recovery of this shorebird. Plots of land owned by the military are being used for recovery efforts, providing breeding grounds for the plover and other threatened birds. The government has also placed a $2,500 fine for the disruption of a plover nest. Other efforts have included the removal of European beach grass, an invasive plant species that has been shown to lead to a decline in plover nesting activity. ("The Snowy Plover Page" 2007)

Additionally, the U.S. Fish and Wildlife Service, California/Nevada Operations office, has created a Recovery Plan for the Pacific Coast Population of the Western Snowy Plover. The objective of this plan, outlined in September 2007, is to remove the plover from threatened

A snowy plover parent feigns injury to draw a suspected predator away from the nest.

species status by increasing its numbers, ensuring its sustainability and monitoring its population. According to the parameters set out by this plan, there is a possibility the plover may be removed from the list by 2047. This long-term recovery plan truly showcases the need for better care of our environment and the species that reside in it. (Hornaday, Pisani, and Warne 2007)

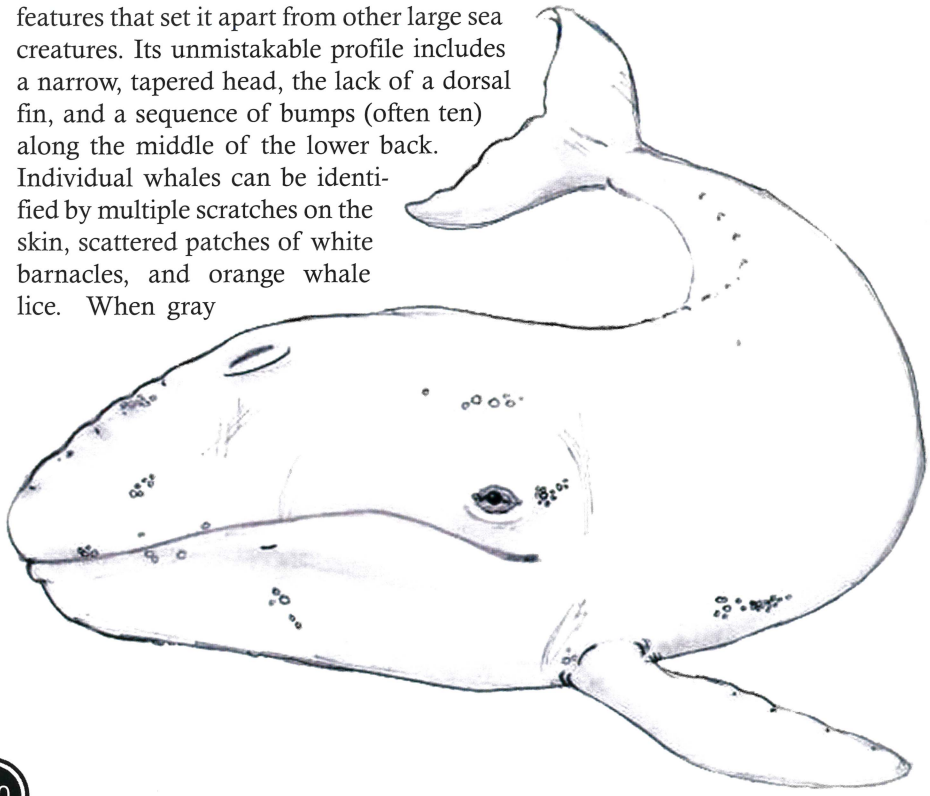
There is still a long way to go before the Western snowy plover can be removed from the threatened species status. Unfortunately, there has been growing outrage from the public because many people are having to give up their beach activities for the plover. Some angry citizens have suggested throwing "Snowy Plover Stomp" barbecues in protest, an example of some of the more radical movements against habitat restoration and species conservation.

Gray Whale

(*Eschrichtius robustus*)

Those fortunate enough to observe the gray whale would agree that it is one of the world's most unique and majestic mammals. It is the only member of the Eschrichtiidae family and has been in existence more than 30 million years, making it one of the oldest mammals on Earth. It also boasts the longest migration of any mammal: an average 20,000-kilometer round trip from the cold Alaskan waters to the warmth of Baja California, Mexico. Once, a number of gray whale populations existed: possibly two in the North Atlantic (now extinct), the western North Pacific (nearing extinction), and the eastern North Pacific (the largest surviving population). The pattern of migration, feeding, mating grounds and calving of the two Pacific populations was different from the other whale populations. The eastern North Pacific gray whale migrates along the Pacific Coast and is frequently visible from the shore as it makes its amazing trek. (Rice and Wolman 1971)

The gray whale has many distinct features that set it apart from other large sea creatures. Its unmistakable profile includes a narrow, tapered head, the lack of a dorsal fin, and a sequence of bumps (often ten) along the middle of the lower back. Individual whales can be identified by multiple scratches on the skin, scattered patches of white barnacles, and orange whale lice. When gray



whales begin their northern journey from Baja California, females whales frequently have newborn calves in tow, distinguished by dark gray or black coloring and white markings. (Watson 1981) (Rice and Wolman 1971)

The gray whale has a curious nature. On occasion, a lucky ocean visitor has the extraordinary experience of encountering "friendlies" that approach boats and do not mind being touched by humans. The Baja California breeding and calving area is where this unique event is most often experienced.

Migration route of the gray whale. It has the longest migration of any marine mammal. The round trip is over 20,000 kilometers.

The gray whale breeds from winter to early spring. It reaches sexual maturity between five and 11 years of age. Courtship and mating behaviors include spy hopping (a sudden thrust of the head straight up out of the water) and circling. The gestation period lasts from 12 to 13 months. The female gray bears a single calf (about about the size of a Volkswagen Beetle) at intervals of two or more years. The calf remains with its mother until it is weaned—usually in the summer following its birth.

A full-grown gray can measure more than 15 meters and weigh more than 27,000 kilograms. Since the whale is so large, it needs an enormous amount of nourishment to survive—more than 60,000 kilograms of food annually, which is about the same amount of food the average human consumes in a lifetime. The gray dredges the ocean bottom for food such as amphipods, polychaete worms and mollusks using its baleen plates (fringed plates that hang from the upper jaw) to filter out mud. When it closes its mouth, water and mud rush out through these plates and trap food. Interestingly enough, when feeding, the gray whale will invariably roll on its right side to suck up substrate spitting a large cloud of filtered dirt from the upper, left side of the mouth. ("Gray Whale" 2007) (Sidenstecker 2007)

It is difficult to tell the age of a gray whale since it has no teeth. However, its estimated lifespan is 50 to 60 years. Because of its immense size, the gray has few natural predators, although occasionally it falls prey to an orca (killer whale) attack. Pods of orcas tend to attack the smaller or younger grays as they are easier prey.

The gray whale enjoys frolicking in the water and sometimes appears to surf the waves. Surprisingly, it is an agile swimmer in spite of its immense size. The gray whale can hold its breath for as long as 30 minutes and can dive to a depth of 150 meters. When one thinks of the gray whale, the most common image that comes to mind is a *National Geographic* shot of one defying gravity as it leaps in the air. This act called breaching, which is accompanied by a dramatic spray of water and is believed to help clean off barnacles and whale lice. It may also be a form of communication between whales, and provides a magnificent spectacle for enthusiastic whale watchers. (Gordon and Baldridge 1991)

Prior to its overexploitation the gray whale migrated in great numbers off San Diego's coast. Richard Henry Dana described the abundance of this species during his voyages along the California Coast between 1834 and 1836. "We were surrounded far and near by shoals of sluggish whales and grampuses [Risso's dolphins], which the fog prevented our seeing rising slowly to the surface or perhaps lying out at length heaving out those peculiar lazy deep and long drawn breathings which give such an impression of supineness and strength." (Dana 1840)

Today, patient observers on the shores of San Diego Bay can spot grays. During the course of this study migrating whales were seen from both ship and shore. We were even fortunate enough to capture on film an adult breaching at the mouth of the bay on its return to northern waters. Mid-January is the peak of its migration south, but the "whale watching" season is traditionally mid-December through mid-March. Typically, the eastern North Pacific gray whale swims south without feeding and can be observed at one-minute intervals as it surfaces to breathe. It is more common to encounter a gray feeding during its northern route to Alaska.

Errant gray whale that wandered into San Diego Bay, March 2009.

O, GRAY WHALE

O, gray whale,
Barnacles line your wry face.
You are tired, so tired
From swimming from place to place.
Breaching along the rugged coast
Watching as others of your kind are taken,
Living in a world where your presence is forsaken.
Such a thing is too horrid to be a lie.
The wake of a ship crosses your path
Flee from the dreaded man
Go with all of your might
Flee as fast as you can.

— Jessica Shutt

Decline of the Gray Whale

Notations in the personal diaries of early 1800s traders commented on the existence of whales in San Diego Bay. However, whaling in the area was nonexistent thanks to restrictions set down by the Mexican government. In addition, the relatively combative nature of the gray whale gave it a distinct advantage when facing off against the hand-held spears commonly used by whalers during that time, so it was safe from humans. However, in mid-nineteenth century a type of harpoon gun, which shot explosive bullets, was developed. Moreover, San Diego had then come under the control of the United States, and some miners from the California Gold Rush, realizing that they were unlikely to strike it rich, looked for occupations in other industries—including whaling. Whalers sailed into the lagoons along the Baja California coast and took females in great numbers. ("Gray Whale Migration Route" 2008) (May 2007)

In 1857, the brothers Prince William and Alpheus Packard arrived in San Diego. They based their shore-whaling operation in La Playa and established a plant on Ballast Point that rendered whale flesh into oil. The brothers, and several other whaling camps, met with great success. Ballast Point was an ideal place because the whales, being coastal migrators, came in close to shore. It also kept the whale-oil plants well away from San Diego residents as they were "horribly smelly—the burning oil was unbearable for most people." (May 2007)

In 1869, Isadore Matthias invested in the Johnson and Tilton and the Packard whaling companies. The Ballast Point whaling stations and those just down the coast at Punta Banda and Santo Tomás harvested more than 20,000 gallons of oil in the 1870–1871 season. The next season yielded 55,000 gallons, and by 1873 the gray whale population had dropped significantly. Consequently, it was probably fortuitous that in 1873 the whalers were evicted from Ballast Point by the U.S. Army, an event that marked the end of their financial backing by Matthias. Various whaling companies from San Diego continued to hunt grays until 1886, but not nearly to the extent of the early 1870s and by 1887, whaling had died out as an industry in San Diego. The whalers drove the gray whale to near extinction; had they continued whaling after 1887, it is possible that there would be no grays today. (May 2007)

The dive of the gray whale is not as deep or as long as that of other whales. Consequently, it was an easy target when migrating through

narrow coastal corridors for its annual, traditional return to the shallow calving lagoons in Baja California. In 1947 the International Whaling Commission agreed that the gray whale should have full protection status. Unfortunately, this did not effectively stop hunting. ("Gray Whale Tutorial" 2008) (Gregr 2000)

Global warming is believed to have caused a fluctuation in gray whale calf production. The Southwest Fisheries Science Center has reported that calf births from 1994 to 2000 fluctuated because of changes in the seasonal ice cover at the North Pole. Moreover, scientists fear that the increasingly frequent sight of emaciated gray whales along the Pacific Coast is an indication that "global warming is wreaking havoc in the whales' Bering Sea summer feeding grounds." ("Save the Whales" 2007)

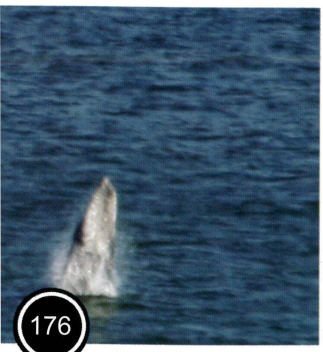
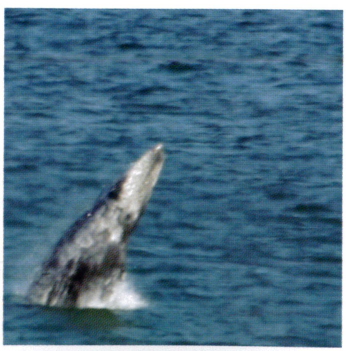
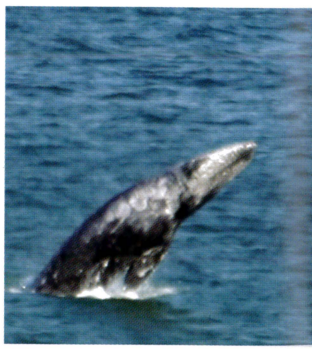
The population of amphipods that once constituted the whale's primary food source is declining, and plankton is being killed by increasing amounts of chlorofluorocarbons as greater ultraviolet radiation passes through our atmosphere. Because the gray needs more than 60,000 kilograms of food per year it is being forced to seek out a much more diverse prey base. Even though humans may not be killing the whale directly, every time they drive automobiles and send more carbon dioxide into the atmosphere, they may be contributing to the degradation of resources the whale needs to survive. (Perryman, et al. 2002) (Sidenstecker 2007) ("Gray Whale Tutorial" 2008) (Gregr, et al. 2000)

Recovery of the Gray Whale

In 1973 the Marine Mammal Protection Act (MMPA) was established by the U.S. government. The act acknowledged the endangerment of a variety of marine mammals and placed restrictions on their exploitation. Recent Marine Mammal Stock Assessment Reports, compiled and produced by NOAA, have shown a dramatic increase in the gray whale population. In 1968 there were only about 13,000 grays, but in 1994, with a population of about 24,000, the eastern Northern Pacific gray whale was removed from the Endangered Species List because it was no longer considered threatened or endangered under the Endangered Species Act. However, the whale's population fell significantly from its 1998 peak of 28,500 to about 18,500 in 2001—a drop of more than 10,000 whales in only four years. ("Gray Whale (*Eschrichtius robustus*)" 2007)

The relative success of the rehabilitation of the gray whale is partly credited to the drop in the animal's population that took place during World War II when the expansion of industrial whaling prompted a depletion of most of the great whale species. As a result, there were more dramatic increases in the gray population than usual, possibly because its primary predator, the orca, had declined in numbers.

In California, military warfare training exercises, using high-powered sonar devices have drawn skepticism from environmental groups as they pose danger to the gray whale and other marine mammals. As recently as the summer of 2006, a California district judge placed a restraining order on one such training exercise, prompting the U.S. Department of Defense to give the Navy a six-month exemption from the MMPA. In January 2008, the same judge ruled that the Navy could not deploy high-powered sonar devices within 12 miles of the California coast. In an unprecedented case, Save the Whales prevented the occurrence of 270 "Ship Shock" underwater Naval tests from taking place over the

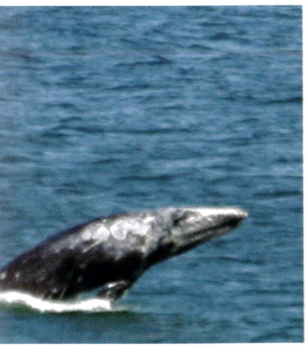




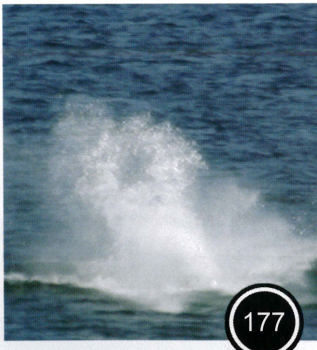
course of five years in the Channel Island Marine Sanctuary. Perhaps as many as 10,000 marine animals would have been killed outright as a result of such tests. (McClure 2008) ("Save the Whales" 2007) (Sidenstecker 2007) ("U.S. Navy in Sonar Ban over Whales" 2006)

Organizations like Save the Whales, which provide insights into the negative human impacts on whale populations, are currently the best means of educating the public and raising general awareness of the fragile position of marine mammals. Ron May, a historian who studied the nineteenth-century Ballast Point whaling camps believes that education such as that provided by Save the Whales has played a vital role in the gray's recovery: "the preservation of their habitats, [and increasing] world awareness of the plight of the whales, that's really why they are back. [However] we always need to be vigilant that somebody won't come back in someday and find an economic use to kill the whales that overrides the need to preserve them." (May 2007) ("Save the Whales" 2007)

Maris Sidenstecker, founder of Save the Whales, when asked which accomplishment she was most proud of in her conservation work stated, "two things: educating over 277,000 students with our hands-on outreach program 'Whales On Wheels'™ and stopping the Navy from "Ship Shock" testing in a Marine Sanctuary." (Sidenstecker 2007) During migration season, Save the Whales' volunteers go out on boats and untangle unfortunate animals that have been caught in stray fishing lines. Save the Whales prides itself on its investments for the future, realizing that there is a great deal of under-utilized interest in whale population preservation, so they feel that it is their job to rally a call for action. ("Save the Whales" 2007) (Sidenstecker 2007)

In addition to Save the Whales, other organizations such as Greenpeace and Sea Shepherd have played considerable roles in the conservation of gray whale populations. Both organizations contribute to the well being of grays, although each organization goes about this in a different way. Greenpeace believes in nonviolent protests against organizations that harm gray whale habitats, while Sea Shepherd takes a more aggressive approach to those who interfere with the whale. Greenpeace, established in 1971, has been a presence in oceans all over





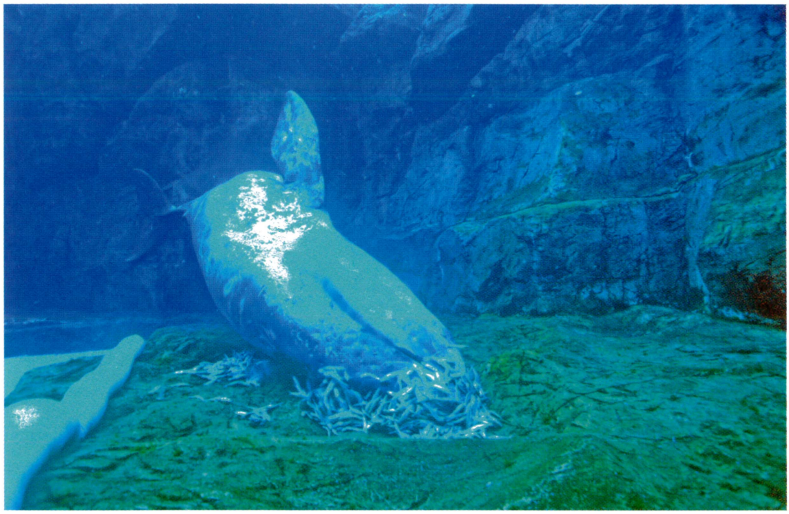
the globe to prevent whale poaching of all kinds as an attempt to rally support for the next convening of the International Whaling Commission. Sea Shepherd has attracted a great deal of criticism because of their unorthodox approaches and destructive protest methods.

The gray whale is one of the few of the great whales to have an infant raised in captivity. On January 10, 1997 near Marina del Rey, California a malnourished and stranded infant gray, no more than one week old, was found in knee-deep water. At the mercy of the receding tide, the infant struggled to stay afloat. When it was discovered that there were no migrating grays in the area, it was decided that to save the whale's life, the female would have to be transported to SeaWorld San Diego without fail. The trip itself took approximately three hours, with veterinarians continually pouring water on the infant to keep it comfortable. (Heyning and Heyning 2001)

The night of the whale's arrival was filled with trials and tribulations for the young calf. Since the infant could not stay afloat on its own, it was placed in a shallow tank, which did not require it to sustain buoyancy. Throughout the night, rescue workers rehydrated the calf and gave it supplementary nutrients and antibiotics to strengthen its weakened immune system. SeaWorld veterinarians then spent the remainder of the night developing a formula for the infant—based on other whales that had been successfully rehabilitated by their program. (Heyning and Heyning 2001)

After two days of work, the veterinarians started the infant on the synthetic formula. At first, feeding was quite difficult, but it learned quickly, and soon associated humans with food. The day after being fed two gallons of the formula the infant gray gained 14 kilograms and would go on to gain around 36 kilograms during its first five days at SeaWorld. When the SeaWorld veterinarians noticed significant improvements in the calf, they decided on the name J.J. to commemorate the late Judi Jones, a longtime advocate of the San Diego sea lion population. Though J.J.'s astounding initial growth rate began to level off, it gained a total of 181 kilograms during the first two weeks at SeaWorld. (Heyning and Heyning 2001)

A month into its stay, J.J.'s weight reached 408 kilograms, so the animal was moved to a larger tank. After eight months it finally learned how to feed at the tank's bottom, thus enabling it to survive in the ocean. The young gray was released on March 23, 1998. J.J.'s rehabilitation is widely considered to be a success, though its whereabouts are unknown. (Heyning and Heyning 2001)



Much was learned from observing the gray whale calf. Here, J.J. feeds on squid at the bottom of the SeaWorld tank.

The successful recovery of the gray whale population gives one hope for the future of marine mammal conservation. Of all the whale species, the gray is the only one to have met with such success. The recovery plans must continue and hopefully more can be learned from this story so that other species that are currently on the brink of extinction may be saved.

Maris Sidenstecker

Devotee to conservation efforts, Maris Sidenstecker founded Save the Whales when she was 14 to promote education about marine mammals and the oceanic environment. This internationally recognized organization has blossomed since then, and is responsible for educating more than 277,000 children to the plight of whales through the program Whales on Wheels™. Sidenstecker's desk is littered with paperwork for her various projects, such as saving countless marine mammals from deaths caused by Navy "Ship Shock" tests, and for preventing salt mining in the last remaining undeveloped gray whale birthing bay. The papers on her desk are merely symbolic of her continuing efforts to protect marine mammals from the hardships they face from mankind's actions.

Student Researcher (SR): How large does the eastern North Pacific gray whale population need to be so it is no longer a concern?
Maris Sidenstecker: This is hard to estimate. The population of 20,000 plus animals is still not a very large population. An overlooked potential danger is the lack of genetic diversity within this species and absence of genetic studies. The effects of global warming and chemical pollution on future generations pose serious questions that lack answers.

SR: At what point did the nation recognize the plight of the gray whale and other great whales?
Sidenstecker: The great whales have been protected since 1986 when there was an international ban on commercial whaling. Even with protection, the only great whale to make a significant recovery is the gray. Due to loopholes in the International Whaling Commission regulations, Japan, Norway and Iceland have been whaling on the small baleen whales or minke whales.

SR: What was your inspiration behind Save the Whales?
Sidenstecker: When I was 14, I went to Boston to visit my father during a summer vacation. The airline magazine contained a story on whales and how cruelly they were killed. I was shocked to read about a pregnant blue whale that had suffered on a dock for several days before dying. I felt people had to know what was happening to the whales. I told my father, who was an art director, that I wanted to design a t-shirt for the whales. He encouraged me to work on the design and what I wanted the

message to be. After much thought I decided what I most wanted was "Save The Whales." This became the message on the shirt along with my drawing of the blue whale.

SR: What are you most proud of as a marine advocate?
Sidenstecker: There are two things. First of all, we focus mainly on education and developed an innovative hands-on program called Whales On Wheels™ (WOW), which we brought to hundreds of thousands of children all over California both in English and Spanish. WOW has been fortunate enough to also travel all over the country.

The biggest effort of Save The Whales was our battle to stop the Navy from performing "Ship Shock" tests in the Channel Islands Marine Sanctuary, a biologically sensitive area off the coast of Southern California. These waters are home to blue, sperm, fin and humpback whales, as well as other marine animals. If the U.S. Navy went ahead with its plans—which was to test the hull integrity of its new cruisers by detonating 270 underwater explosives—it was estimated that 10,000 marine mammals, including many endangered whales would have been killed outright.

We took this issue to court in the U.S. District Court, (Central District), in downtown Los Angeles. Judge Stephen V. Wilson presided and at the end of the five-day hearing, he found that "the Navy had failed in its obligation to protect marine mammals; that it hadn't prepared a full environmental impact statement; and that it hadn't investigated all reasonable alternative sites and properly mitigated the impact of detonations on marine life." In the end, one detonation would be allowed farther offshore with observers of our choice, including airplanes, and instruments would be used to detect any deep-diving marine mammals.

SR: What do you believe needs to change for the increase of global whale populations?
Sidenstecker: The following: (1) a new governmental leadership that will have an environmental policy; (2) the cessation of low-frequency underwater weapons testing, which is found to damage cetacean hearing and has been linked to beached whales; (3) protection of ocean habitats; (4) preventing urban runoff; (5) curtailing global warming that affects plankton, the beginning of the entire ocean food chain; (6) stopping whaling completely.

Invasive Species

"It would be hard to say that an invasive species has no affect on the ecosystem, especially if it is surviving."

— Jamie Gonzalez

Invasive or introduced species have long been a problem for ecosystems worldwide. Over the course of history, plants, animals and microbes have accompanied man as he migrated across the globe. These introductions of new species as humans moved about the planet have been both purposeful and accidental. (Diamond 2005)

When species disrupt the ecological balance of their new environment they are considered invasive. The most common reasons for introducing species in ancient times were either for survival or cultural nostalgia. Migrating farmers knew only the plants and animals from their homeland. Therefore, to make themselves feel more comfortable in their new environment, they sometimes brought familiar species with them to make their new home feel more like the old. When the British colonized Australia they brought rabbits and foxes because of nostalgia for the animals of the English countryside. Both these species, particularly rabbits, have caused serious ecological problems in Australia with their destruction of native vegetation. People also brought plants or animals along in case they would not have ample food sources in their new home, or familiar food would not be available. (Diamond 2005)

Today, the problem of invasive species is more common and severe because of another human activity: the widespread movement of boats and commercial vessels. Global trade and transport can introduce species into new environments unintentionally, and even the smallest of species can have a large impact.

According to James T. Carlton, an ecologist who has extensively studied the effects of invasive marine invertebrates in Northern California, there are four primary means by which species have been introduced into the estuaries of San Francisco and the surrounding region. These are hull fouling, ballast water, the commercial oyster industry, and the importation of commercial bait and fresh seafood. (Carlton 2001)

Wooden ships that docked in Central California's bays two centuries ago may have been responsible for the introduction of "fouling" marine organisms from the shores of the Atlantic Ocean. Ship fouling gets its name from the organisms that bore, or foul, holes in a ship's hull or attach themselves to its surface. These organisms can find their way into the ship at one location then, in the case of a transcontinental voyage, be released at one of the vessel's docking points. Within a few days, a foreign and potentially harmful species can arrive thousand of miles from its natural habitat.

During the days of the California Gold Rush, many ships were abandoned in San Francisco Bay, allowing fouling organisms to run rampant. To this day, San Francisco Bay is one of the most heavily invaded estuaries in the world. Some prime examples of invasive marine organisms there are the Atlantic barnacle (*Balanus improvisus*) and the Western Pacific shrimp (*Palaemon macrodactylus*). Later the green crab (*Carcinus maenas*) in the region has created an environmental crisis, nearly wiping out the presence of soft clams on the Northern California coast, and creating a significant disruption in the feeding habits of local shorebirds. (Carlton and Zullo 1969) (Van Heertum 2002)

Antifouling paints have been used in the past for controlling the introduction of invasive species. Many boaters used a copper-based paint to repel species that attached to the unprotected hulls. This caused environmental problems as the copper, a toxic pollutant, was slowly released into the water. Further research has shown the development of copper-tolerant species that not only survive on treated ship hulls, but thrive in copper-polluted waters. Fortunately, copper is not the only method for protecting ship hulls; alternative and effective nontoxic antifouling paints for ship hulls are available. However, the threat of species introduction cannot be expected to disappear entirely and more steps must be taken to ensure the threat does not continue. (Carlton 2001) (Gonzalez 2007)

Another common method of introduction is through ballast water, which is collected and distributed into the ship's internal compartments to balance cargo. This water is dumped before or during docking. The problem is that organisms from the ship's original port are released into its destination's harbor. During the last

century, the Chilean beachhopper (*Orchestia chiliensis*) was introduced by lumber ships returning to San Francisco Bay, and in the 1950s ships returning from the Korean War introduced the oriental shrimp (*Palaemon macrodactylus*) in this way.

Recent studies have also shown the importance of monitoring shorter voyages that may be responsible for the spread of invasive species. (Wasson, et al. 2001) A number of the invasive species in Los Angeles and Orange Counties are threatening to the environment. If boaters are not careful, these species could arrive in San Diego Bay in the near future.

A third means of introduction is the commercial shellfish industry. Oysters, such as the *Crassostrea virginica* from the Atlantic coast, may act as vectors for certain organisms, which lodge themselves inside the animals' shells, and escape during shipping and handling. Although stricter measures have been enforced in the aquaculture industry today, many invertebrates can still elude these regulations and cause damage. (Carlton 2001) An example of this is the sabellid polychaete introduced from South Africa that nearly destroyed the California abalone industry. It is thought to have been transported to California on imported broodstock animals. (Culver, Kuris, and Beede 1997) There was great concern that this parasitic worm would be introduced to wild abalone populations.

The final means of introduction outlined by Carlton is commercial bait importation. Worms for West Coast bait-and-tackle shops are packed in algae, which may be discarded in local waters after the shipment arrives. These algae may contain numerous invertebrates with the potential for harm to the local ecosystem. The presence of the Atlantic periwinkle (*Littorina littorea*) in San Francisco Bay can probably be attributed to this action, and the Atlantic quahog (*Mercenaria mercenaria*) has also been found in Humboldt and San Francisco Bays. (Miller 1969)

Possibly the most problematic species in San Diego Bay is the Asian or Japanese mussel (*Musculista senhousia*). This mussel hinders the growth of certain native organisms such as eelgrass and various species of clams. A reduction in eelgrass and clam numbers may lead to a declining fish population that may also directly affect bird populations and, to a lesser degree, humans. From this example, one can see how a species such as the Asian mussel can have a devastating effect on many other species and the ecosystem as a whole. (Carlton 2001)

In June 2000, a potentially devastating invasive marine algae, first discovered in a Carlsbad coastal lagoon, raised a serious alarm in both Southern California and the entire nation. Dubbed the "killer algae," the highly invasive seaweed (*Caulerpa taxifolia*) had nearly destroyed the biodiversity of an area of the Mediterranean Sea.

The Southern California *Caulerpa* Action Team (SCCAT) was established. Because of their fast and effective response, all the patches of *Caulerpa* on the lagoon floor were treated with chlorine held beneath a tarpaulin. This method was successful in killing not only the plant but its subterranean parts. The cost for eradicating the "killer algae" was $7 million. Additionally, the value of the loss of other species in the treated habitat was considerable. (Woodfield 2000)

The algae continues to pose a substantial threat to marine ecosystems in Southern California, particularly to the extensive eelgrass and kelp beds. Banning *Caulerpa* in the aquaria trade, educating the public on its threat to local waters, and continual monitoring will help to reduce the risks of future catastrophes.

Many people do not understand the gravity of the situation and have purposefully released species into local streams or bays. Home aquaria are sometimes dumped into nearby waterways when the owners no longer wish to maintain them and are reluctant to flush the contents down the toilet. The local invasion of *Caulerpa taxifolia* is thought to have originated from such action. Plants and animals from home aquaria should never be dumped outdoors into waterways. See www.habitattitude.net for better alternatives.

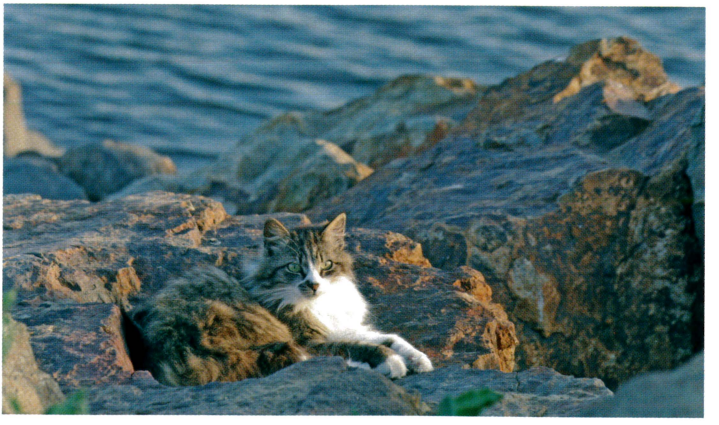
There are two primary means for slowing the introduction of invasive species. First is the preventative route: international ship-

An invasive Asian mussel (*Musculista senhousia*) was collected on Grape Street pier, DNA barcoded, and identified by students at High Tech High.

ping regulations that require vessels to exchange their ballast water in mid-ocean. Another is the application of the most effective kind of anti-fouling paint. And, to combat species such as the copper-resistant algae *Ectocarpus siliculosus*, regular hull cleaning paired with the application of alternative, nontoxic bottom paints to reduce invasive species. Taking these precautions will hopefully limit the numbers of invasive species and their transport around the world, although the problem will not be solved entirely. (Carlton 2001)

In addition to preventative measures, well-considered and even "natural" abatement processes will have to be undertaken to reduce the problem of invasive species. For example, *Caulerpa taxifolia* can be defeated with chlorine treatment or with a species of slug that feasts on

A close-up of *Caulerpa taxifolia* growing among eel grass shoots in Agua Hedionda Lagoon in Carlsbad, CA.



Domestic and feral cats are predators of many endangered bird species of the bay.

the seaweed. Many other invasive species, however, have no currently known enemies, because scientists have little knowledge of which species may damage an ecosystem. Analyzing life histories and nutritional requirements, as well as natural predators may help solve the problem. Finding out where an invasive species originated is key, because then it can be tested against other species from the same location. For example, this could be a means for locating an effective predatory species to remove the species in question. Establishing trends in abundance and the origin of an invasive is important to understand the species and detect its presence before its numbers become extensive. One recommendation is DNA barcoding. This method would allow the identification of stages of an organism's life history that would otherwise be difficult to classify. During the course of this High Tech High study, zooplankton were identified using this method. Implementing this testing on a larger scale could allow the immediate identification of a pioneer member of a newly introduced population.

A challenge in creating effective action in dealing with invasives is the difficulty in determining the biogeographic origin. There are many invasive species, such as the tubeworm *Mercierella enigmatica* (found in San Francisco Bay) that was thought to be from France, but has now been found to be of Indonesian origin. Misconceptions like this can slow down the process of abating the damage to an ecosystem caused by an invasive; without a background analysis of a specific species, it is difficult to figure out its dietary needs or its physical weaknesses. For an invasion to be stopped, a dedicated team of researchers is required. Funds need to be allocated and the general public made aware of the problem and its severity. (Hyman 1955)

With increased globalization and importation of goods, the introduction of invasive species will probably increase. Therefore, action needs to be taken to avoid large-scale destruction of our local waters. Since prevention is widely considered to be the best path, researchers, politicians and local citizens should work together to bring about a preventative plan for San Diego Bay.

Stricter regulation of marine vessels is necessary to slow the introduction of invasive invertebrate and algal species, but it is not the only solution. Invasive species may be the result of human leisure activities and are thus difficult to control or stop. The best way to end the problem is to educate and warn people about the hazards of these species, and their effect on ecosystems (see www.protectyourwaters.com).

Hopefully, San Diego Bay will prove to be a good case study for how well preventive measures can work. It is doubtful that measures will ever exist to eradicate the present diverse set of

invasive species in and around San Diego Bay. However, effective strategies should continue to be researched and developed to halt future invasions.

The Mediterranean mussel, *Mytilus galloprovincialis*, was DNA barcoded by High Tech High students.

Jamie Gonzalez

As a Program Representative, Jamie had worked for the University of California Cooperative Extension/Sea Grant Extension Program since 2002. She received a bachelor's degree from the University of San Diego in Ocean Studies and a master's in Marine Affairs and Policy from the University of Miami. Most recently, she conducted research on the sustainability of water quality and coastal resources. Some of her other work included the prevention of invasive species on boat hulls as well as nontoxic antifouling strategies for recreational boats. She disseminated research-based information to the government, businesses, scientific representatives, in addition to environmental organizations and vessel owners.

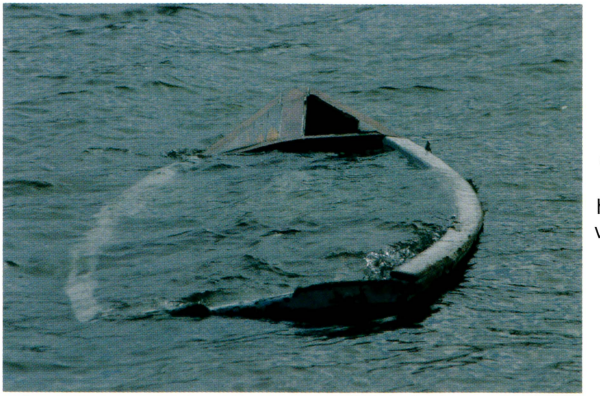
Student Researcher (SR): How would you define invasive species?
Jamie Gonzalez: An invasive species is a species not native to the area where it is found.

SR: Do you think that most people who introduce species know what they are doing, or they are clueless about their actions?
Gonzalez: I think most people are not aware what they are doing because if they knew the effects, then they would probably not be doing it. They are just totally unaware that their actions can have consequences.

SR: What are a few of the most common means of introduction?
Gonzalez: Some are introducing invasive species through ballast water, also through aquaculture and, more recently, we have heard about introducing species on boat bottoms.

SR: Could you tell us a little bit more about ballast water?
Gonzalez: Ballast water is needed for ships to even out their weight. When they pull into port, the ships end up emptying out their ballast water as they unload their cargo. So, all the ballast water from their original port is brought over to their destination, which could be another continent.

SR: What percentage of invasive species end up becoming detrimental to their new ecosystem?
Gonzalez: Every species that is invasive into an ecosystem in which they're not native ends up altering that system in some way; so maybe



Boats are occasionally abandoned in the bay and can become hazards for both other vessels and for wildlife when fouling organisms are released.

all of them. It would be hard to say that an invasive species has no affect on the ecosystem, especially if it is surviving.

SR: What are some of the more infamous invasive species?
Gonzalez: In the United States this would be the zebra mussel. That's because it has caused so much harm in the Great Lakes, clogging up water pipes and overtaking the ecosystem there. I think that's the most famous invasive species and now a relative of the zebra mussel is coming into California—the quagga mussel.

SR: What are some of the most current ways of preventing invasive species?
Gonzalez: This is education—educating boaters, for example, on how to prevent bringing invasive species on the bottom of their boats may greatly deter the spreading of these species to other areas.

SR: Do you believe that most governments are aware of the problem of invasive species but just don't have the resources, or do you think they choose to ignore it?
Gonzalez: In some cases, governments might choose to ignore the problem because many times they don't see the direct impact of invasive species. Then again, funding might be a problem as well. In the United States, a 2007 bill was introduced called the National Aquatic Invasive Species Act. So, they are making it a priority to put funding towards invasive species prevention.

SR: What is your opinion on using other species to combat invasive species that are already established?
Gonzalez: This is really risky, because you're going into that ecosystem and introducing something new. There's already an invasive species

there and you don't know really what's going to happen to all the other species there after you introduce a new one. So, even though you're there to help by bringing in this new species, I think its impossible to say what could happen. So I don't totally agree with it.

SR: What are some of the reasons that point to prevention being the best approach?
Gonzalez: Prevention is less expensive than eradication, which can cost millions of dollars. If you prevent the invasive species from getting there in the first place, that's going to be less expensive. You're not going to have to deal with the consequences or impacts of invasive species being in the environment.

SR: Is there anything else you would like to say in conclusion about invasive species?
Gonzalez: Invasive species issues are coming more into the limelight. The public knows more about them now. For example, back when I was in high school, I don't remember talking about invasive species very much, but in college we definitely did. So, I think people are becoming more aware, although there are always those who never get the information. And, I do think governments are making it more of a priority.

Endangered Species Act

"It is important to have ethics—a shared moral dedication—to conserve the natural world."

— Rachel Muir

Some believe legal acts were needed much sooner to save the likes of the Carolina parakeet and the once prolific passenger pigeon. Those North American birds are gone forever, but we now have a law to protect species who need protecting. In 1973, a new and unique approach to the conservation of species was codified. This new concept was created with Congress rewriting the Endangered Species Preservation Act (ESPA) under the Nixon administration; this revised law was called the Endangered Species Act (ESA). With this new legislation, endangered and threatened species would be more effectively protected. The ESA allowed both plants and invertebrates alike to be listed as endangered, and provided protection by making it illegal to harm any listed species or its environment. (O'Toole 1996)

The ESA became and remains a powerful element of species preservation in the United States because, as former president Richard Nixon once said,

> "Nothing is more priceless and more worthy of preservation than the rich array of animal life with which our country has been blessed. It is a many-faceted treasure, of value to scholars, scientists, and nature lovers alike, and it forms a vital part of the heritage we all share as Americans." ("The Endangered Species Act" 2007)

The earlier law—ESPA—was created when the whooping crane neared extinction and congress recognized it was a significant issue. The U.S. Secretary of the Interior was authorized to create a list of endangered wildlife associated with the ESPA, and was given $15 million annually to create habitats for listed species. In 1969, the law was revised and broadened to include the protection of whales in the nation's waters. The secretary could also include foreign endangered species in the list and prohibit the importing of products made from them. (O'Toole 1996)

Even with these newly adopted powers, the ESPA was deemed inadequate. Consequently, with the ESA came many new tools to address and strengthen the laws regarding the world's threatened wildlife:

1. Simple Protection: Protection from hunting, which in the case of the American or Mississippi alligator (*Alligator mississippiensis*), was all that was needed to revitalize its population. In Mississippi, the alligator was hunted for its valuable hides and especially for its underbelly, which could be used in high-quality leathers. Unfortunately for the Mississippi alligator, unregulated and unrestricted hunting was rampant before the ESA came into effect. Today the alligator is a recovered species. (Sherry 1998)
2. Controlling Pollution:Banning dangerous pesticides, such as DDT, was a step that saved the majestic bald eagle (*Haliaeetus leucocephalus*) and several of the avian protagonists of this book. In 1947, when the bald eagle population dropped rapidly, it was discovered that DDT, a pesticide used to control mosquito populations, was the culprit. Unfortunately, fish ingested runoff containing DDT, and the eagle ate the fish. As was true for many other species, the pesticide weakened the eagle's eggs to the point where they would be crushed under the weight of the incubating parent. Since the banning of DDT on December 31, 1972, the


eagle population has risen from about 500 pairs in the 1960s to approximately 9,800 breeding pairs today. (Sherry 1998)

3. Critical Habitat Protection: Restricting most human activities in a specific habitat helped bring back the black-footed ferret (*Mustela nigripes*) from near extinction. In 1981, after the ferret was believed to be extinct, an isolated population of 129 animals was discovered in a prairie-dog colony outside Meeteetse, Wyoming. A number of the endangered ferrets were trapped by the Wyoming Game and Fish Department for a captive breeding program and after some years were released into a new location, the Conata Basin/Badlands Reintroduction Area of South Dakota. Human activity is restricted in this habitat so that the ferret population has a safer life. (Sherry 1998)
4. Conservation and Recovery Plans: These are formal statements of the tasks needed to re-establish a species. For example, the recovery plan for the black-footed ferret required breeding programs, the creation of a restricted habitat, an increase in free-ranging breeding adults, a reintroduction of the species into natural environments, and ongoing monitoring efforts, all before the year 2010. (Sherry 1998)
5. Captive Breeding: Individuals are captured in the wild and relocated to a protected facility where breeding programs are carried out. Because captive breeding requires controlled conditions for a species to prosper, it can be the most difficult means of species re-establishment but it can also be the most successful when dealing with an endangered species. An example of successful captive breeding would be the California condor (*Gymnogypus californianus*). In the 1980s there were only 21 birds remaining in the wild and in captivity combined. With the help of some captive breeding, in 1998 the bird's numbers had risen to 93 captive and 39 wild (released) condors, a dramatic increase in population. (Sherry 1998)

Causative agents used to evaluate the listing of species regulated by the Endangered Species Act (e.g., pollution, invasive species, loss of habitat, exploitation, climate change).

Despite the government's good intentions, there remain several main reasons for continued cause and concern surrounding Despite the government's good intentions, there remain several main reasons for continued cause and concern surrounding the ESA. First, between the years from 1973 to 1995, the ESA could not prevent the extinction of 108 species—an average of five species going extinct each year—meaning the nation's wildlife was clearly still at risk. One main cause for extinction was and remains that species were not added to the ESA listing quickly enough for them to benefit. Of the 108 species that became extinct during that period, 83 experienced long delays in gaining protection: 29 were extinct before being listed; 42 during a delay in the listing process, and 12 after a lengthy delay during which their numbers became too depleted to survive. (Suckling, Slack, and Nowicki 2004)

Second, the Department of the Interior faces conflicts with landowners over financial losses due to ESA regulations. For example, the endangered gray wolf (*Canis lupus*) is listed and their numbers have

The Carolina parakeet was once common in the Eastern United States and as far west as Nebraska. It was considered extinct in the 1920s.

now risen from just a few hundred to over 3,000. With this wolf population increase, livestock and other farm animals are being killed. However, a farmer or private landowner can be fined as much as $100,000 and face possible jail time for killing a protected animal. So, while the ESA benefits the wolf, it hurts many ranchers and farmers, and some rural Americans believe it is a poor trade-off. (Kostel 2008)

Third, it could be argued that the Department of the Interior does not have equitable distribution of its funding; more than 50% of its budget goes to just ten vertebrates. The uneven financial support of endangered species is an issue that needs to be addressesd. (Shrogen 2005)

Last, the public has lost interest in the ESA. Factors include: low media coverage; perceived lack of support by former administrations, and a sense of disconnect—the average U.S. citizen does not dwell on the fate of a threatened species over their own socio-economic concerns. Stories such as the imminent closure (at time of writing this book) of the Chula Vista Nature Center, a long-time supporter of endangered species, demonstrates the changing viewpoint of a local city government on the issue (see Stewards of the Bay chapter for more on this). However, even with this decline in public interest, the ESA still strives to protect endangered U.S. and foreign species.

As of February 28, 2007, the U.S. Fish and Wildlife Service (USFWS) listed approximately 1,350 species on its database, the Threatened and Endangered Species System (TESS). Unfortunately, TESS is purely for information. For a species to receive protection, funding and support necessary for rehabilitation, it must be listed under ESA. ("Working Together" 2007)

In San Diego Bay there are a number of different species that are not only in the TESS database, but are also protected under the ESA. One of these, discussed earlier in this book, is the Western snowy plover (*Charadrius alexandrinus nivosus*). This small shorebird is currently being monitored, as required by the USFWS. Fortunately for the species, it has a recovery plan that includes the restoration of critical habitat on the Pacific Coast. The plan requires

the snowy plover to have 3,000 breeding adults for ten years, and an average annual productivity of at least one fledged chick per male. ("Species Profile: Western snowy plover" 2007) Another endangered species discussed earlier in this book is the light-footed clapper rail (*Rallus longirostris levipes*), a species of particular significance to San Diego that is currently receiving additional support because of its endangered status. This bird is a long-toed, long-legged, hen-sized marsh bird and was listed on the ESA on October 13,1970. The light-footed clapper rail has seven Habitat Conservation Plans (HCP) and one Safe Harbor Agreement (SHA), making a total of eight conservation plans dedicated to its rehabilitation. The clapper rail also receives additional support beyond that of the ESA from organizations including the Tijuana River National Estuarine Research Reserve. ("Endangered and Threatened Bird Species at the Tijuana Estuary" 2007) ("Species Profile: Light-footed clapper rail" 2007)

In addition to the federal ESA, there is also the California list of threatened and endangered species. This is similar to the ESA because both aim to protect fragile wildlife, create and monitor recovery plans, and work with organizations and landowners to benefit select species. Two plant species were added to the state list between 2001 and 2002: the Baja California birdbush (*Ornithostaphylos oppositifolia*) and the Orcutt's hazardia (*Hazardia orcuttii*). ("The Status of Rare ..." 2008)

There are many organizations that have formed to support endangered species. One is the Peregrine Fund, originally created to reverse the declining peregrine falcon (*Falco peregrinus*) population. This nonprofit organization helps birds-of-prey through captive breeding and other means. The Peregrine Fund works solely through private donations that are used in more than a dozen different national and international projects. One of these is restoring the California condor population in Arizona; the Peregrine Fund released and monitored 14 condors in 2005. The Peregrine Fund demonstrates how the general public can benefit endangered species through such programs. If the public were to become more aware of organizations like the Peregrine Fund, the crisis of declining populations might become a thing of the past. ("The Peregrine Fund ..." 2007)

The most likely change to the ESA in the future will be a provision that gives regulatory incentives to private land owners when they support a listed species. Under the SHA, Texas ranchers helped to restore the endangered Northern aplomado falcon (*Falco femoralis*) on their land. The process has also worked for the gopher tortoise, red-cockaded woodpecker, Schaus swallowtail butterfly, and a number of other endangered species. This is one way the ESA can


The snowy plover and least tern have protected nesting sites in San Diego.

be changed in the future to make it efficient enough to stay in effect. ("The Endangered Species: A Backgrounder" 2007)

Besides the ESA, there are many other ways in which endangered species can be helped; conservation research and increased environmental/ecological law enforcement are two of the most important. Conservation research will benefit endangered species not only directly, but through outreach efforts to the general public, especially its younger members who are the next generation of politicians, business owners and citizen activists. If people learn to help endangered species early in life, they can later help to influence public opinion to change the fate of many of the most at-risk plants and animals. An increase in law enforcement will help to protect endangered organisms by defining restrictions, limiting access to protected habitats, and otherwise reinforcing fines and sentences for those who harm the environment. With awareness and an enforced legal system, species protected by the ESA will have long-term positive outcomes and the potential to affect the nation's wildlife as a whole. (Ezcurra 2007)

Education is also important in helping our endangered species. If the United States and other nations around the world can teach the public about the impacts of their everyday lives, they will be able to understand how they are affecting the next generation. Only then can we have the reform that will lead to lasting, positive results. (Ezcurra 2007)

Rachel Muir

Over the course of our research, we were fortunate enough to come into contact with Rachel Muir, the Imperiled Species Coordinator of the U.S. Geological Survey. We could think of no better person than her to shed light on the subject of the Endangered Species Act (ESA) from firsthand experience. Muir is also the great-great-great-grand niece of the renowned naturalist, John Muir, the founder of the Sierra Club. She has followed the family tradition of conservation, endeavoring to preserve the vulnerable gems of America's biodiversity. Muir graciously received us at her office in Reston, Virginia and provided an incredible opportunity to hear from one of the most esteemed experts in the field of conservation.

Student Researcher (SR): How did your familial connection to John Muir impact you?
Rachel Muir: For starters, perhaps the long legs and strong back that have helped me explore the natural world are a gift from my ancestor! More likely is that his ideas—particularly the idea that all parts of the living and nonliving world are connected and bound together—have inspired me to understand and conserve the natural world.

SR: Can you explain the Imperiled Species Coordinator position?
Muir: Many kinds of taxa (species, subspecies and populations) of animals and plants are threatened with extinction. Many others have seen their numbers and their geographic distribution dramatically reduced because of a variety of threats. Most losses in species abundance and distribution are caused by human activities, such as changing habitats, (for example, forests to cities or wetlands to agriculture), introduction of invasive species, and exposure to contaminants, or climate change. As the Imperiled Species Coordinator, I assist our agency in directing and monitoring our research to find out what causes species declines and extinction and how they can be restored.

SR: What is an imperiled species?
Muir: It is one that has or is threatened with a biologically significant decline in population or geographic distribution. More properly, I am referring to imperiled biological resources; this includes species, and the finer taxonomic divisions of subspecies and populations, and the "big picture" level of habitats, biological communities and ecosystems. There are entire communities, such as the tall grass prairies of the Central

United States, or the mangrove forests of Florida and the Caribbean, that are nearly exterminated from their natural range.

SR: How do imperiled species relate to the Endangered Species Act?
Muir: "Imperiled" is a general term that, unlike "endangered" or "threatened," does not have a specific legal definition. It is a handy general term for species and habitats in significant decline. Not all species that are in serious decline actually get listed. We still know relatively little about the status of many species, the causes for their decline, and how they might be recovered. About 1,350 species are listed as threatened or endangered under ESA, but only a handful have been de-listed and fully recovered. Included among the species recovered are the bald eagle and American alligator.

SR: In your own words, what is the Endangered Species Act?
Muir: The ESA is a law that is one of the principal ways in which the U.S. government shapes its policies to protect endangered and threatened species of animals and plants and their habitats. The ESA has established a definition for threatened and endangered species, a procedure for listing them, and a process for de-listing them if they are fully recovered.

SR: Why is the ESA important?
Muir: It is one of the principal legal tools to protect biological diversity. Protecting all kinds of biodiversity is important—not just the handsome, feathered and furred creatures that attract the most attention. The ESA can be used to protect all species of animals or plants, (although it has never been evoked to protect a microorganism such as a bacteria or virus). Like the many parts of a complex machine such as a computer, each part has a role to play. What happens when you remove any part of a complex machine? Can it fail? How much more complex are the ecosystems on which we depend on for our lives and livelihoods! That is the importance of the ESA and other statutes that guide us in conserving our natural resources—the ESA helps us protect the parts of ecosystems called species. However, as you know, ecosystems are part of a complex mixture of living and nonliving things. And human beings as well! In my opinion, laws are helpful and necessary in guiding our activities and behavior. What is more important is that we have an ethic—a shared moral dedication—to conserve the natural world.

SAN DIEGO BAY

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