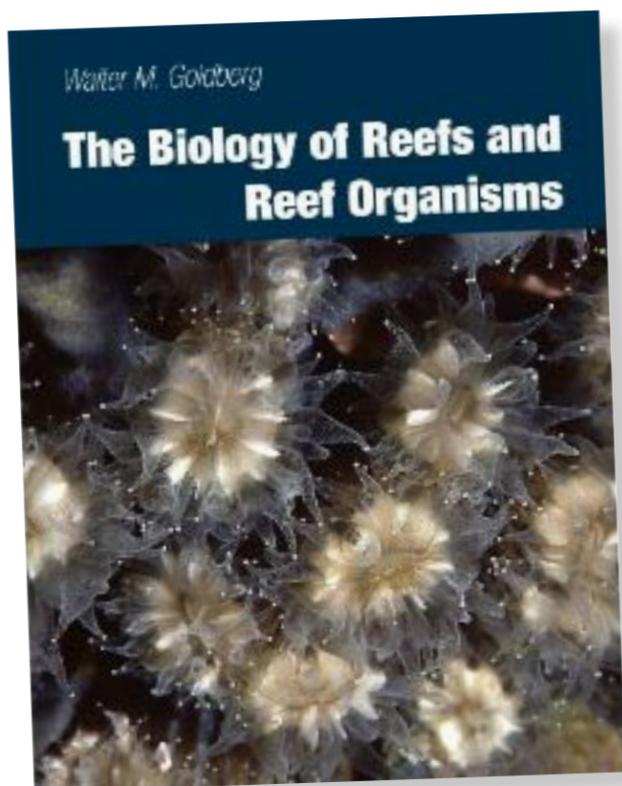


Edited by  
Catherine  
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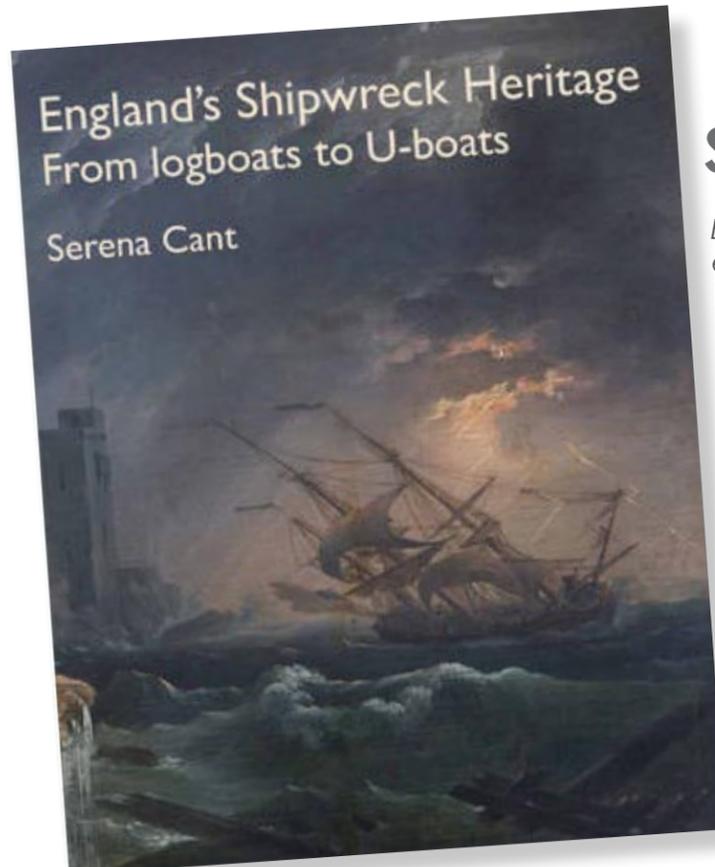


## Biology of Reefs

*The Biology of Reefs and Reef Organisms* by Walter Goldberg. Welcome to Reef Biology 101. If you are keen on reefs, check out this book. It is the result of years of teaching and research into this topic. Besides the quintessential coral reef, the book also covers sponge reefs, worm reefs and oyster reefs.

Areas covered include reef construction, ecology, paleontology, biogeography and conservation, as well as the factors that influence their growth, structure and distribution. Even the organisms that interact with the reefs are depicted. Illustrations are found throughout the book, which promises to be a comprehensive introduction to this fascinating topic.

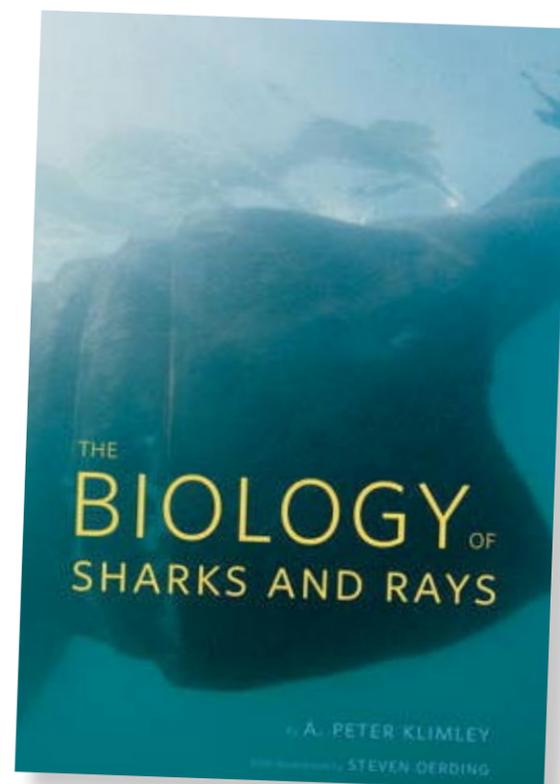
Hardcover: 424 pages  
Publisher: University of Chicago Press  
Publication Date: 15 July 2013  
ISBN-10: 0226301672  
ISBN-13: 978-0226301679



## Shipwrecks

*England's Shipwreck Heritage: From logboats to U-boats?* by Serena Cant. Published by English Heritage, this book shares the stories behind the shipwrecks along the English coast and the territorial waters, dating back from the Anglo-Saxon times to 1945. The shipwrecks range from logboats, Roman galleys, medieval cogs to fishing boats, ocean liners and warships. To give readers a proper perspective, the shipwrecks are depicted within the archaeological, social, economic and naval context, particularly in relation to England's broader historical landscape. Backed by solid research and illustrations, this book is ideal for anyone keen on England's maritime history.

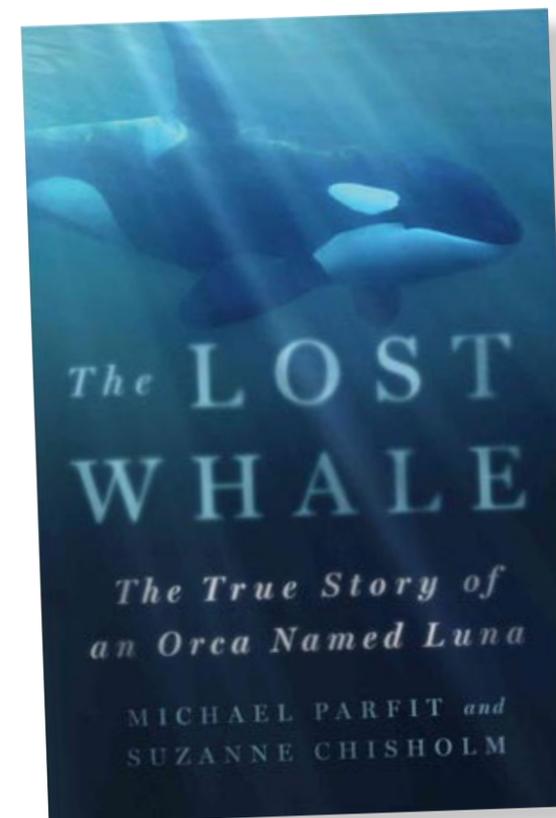
Paperback: 320 pages  
Publisher: English Heritage  
Publication Date: 31 July 2013  
ISBN-10: 1848020449  
ISBN-13: 978-1848020443



## Sharks & Rays

*The Biology of Sharks and Rays* by A. Peter Klimley. Once upon a time, cartilaginous fishes swam in the oceans over 455 million years ago. These species evolved to become the sharks, rays and chimaeras of today. In this book, A. Peter Klimley explores the myriad of information concerning the biologies of these creatures. His extensive knowledge fills up 16 chapters, covering the taxonomy, morphology, ecology and physiology. In addition, each chapter contains snippets of the author's personal experiences, thought-provoking questions and recommended readings. In all, this book looks set to be an extensive reference text for anyone interested in ichthyology.

Hardcover: 488 pages  
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Publication Date: 29 July 2013  
ISBN-10: 0226442497  
ISBN-13: 978-0226442495

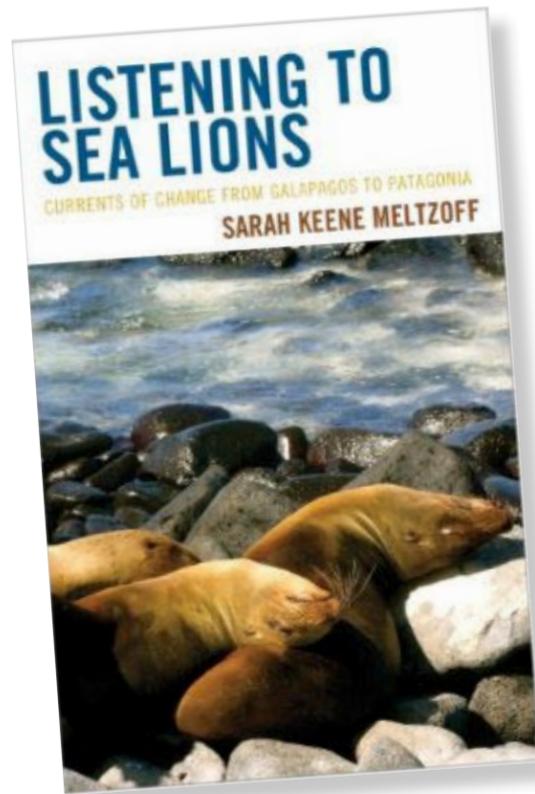
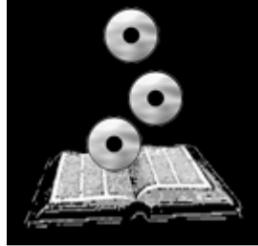


## Luna

*The Lost Whale: The True Story of an Orca Named Luna* by Michael Parfit and Suzanne Chisholm. Once upon a time, in Nootka Sound, on the west coast of Vancouver Island, a friendly young orca got separated from his pod. Lost and alone, he tried to make friends with people instead. He hung around boats and docks, squeaking at the humans on top. Over the years, many people responded positively. They named him Luna

and regarded him with affection. Others wondered if the young orca might be happier living with his own kind, and they constructed a big net. Based on actual events, this book chronicles Luna's story, an orca who even today continues to enchant those who learn of his story.

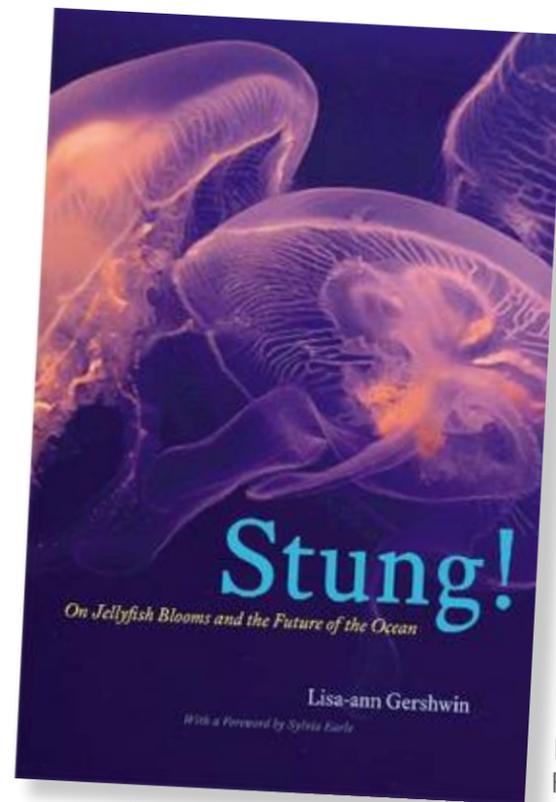
Hardcover: 336 pages  
Publisher: St. Martin's Press, First Edition  
Publication Date: 25 June 2013  
ISBN-10: 0312353642  
ISBN-13: 978-0312353643



## Sea Lions

*Listening to Sea Lions: Currents of Change from Galapagos to Patagonia* by Sarah Keene Meltzoff. This book relates the author's experiences originating from 17 years of ethnography in Chile, the Galapagos Islands and Peru. In it, we read about fisheries booms, subsequent management decisions, the survival strategies of the coastal people and the competition that exists in fisheries, tourism and conservation. Her interactions with the people involved, together with her jargon-free narrative, gives us a glimpse into the lives of the various communities—human and animal—living there.

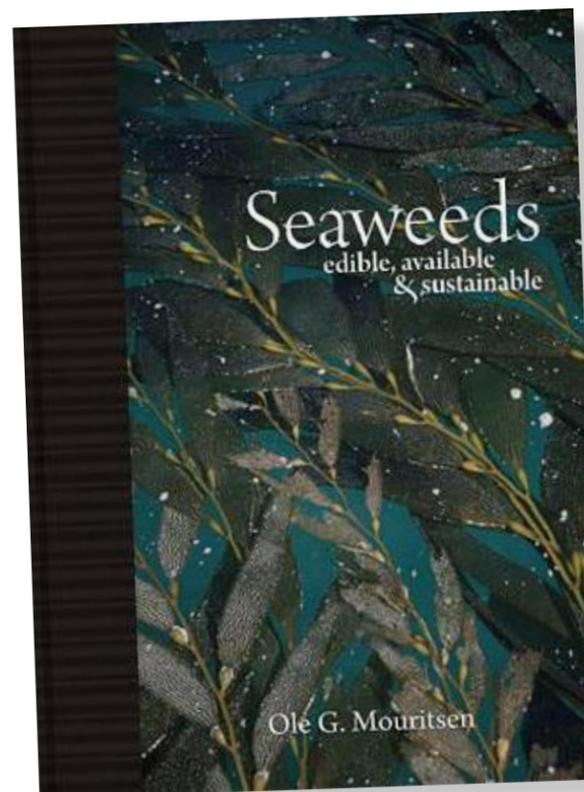
Hardcover: 292 pages  
 Publisher: AltaMira Press  
 Publication Date: 14 December 2012  
 ISBN-10: 0759122350  
 ISBN-13: 978-0759122352



## Jellyfish

*Stung!: On Jellyfish Blooms and the Future of the Ocean* by Lisa-ann Gershwin; Forward by Sylvia Earle. What an appropriate title for a book on jellyfishes—though that's not to say it describes a desired outcome of an encounter with these creatures! While jellyfish are without doubt beautiful and enigmatic, the warmer temperatures of today have encouraged their rapid growth, leading to more incidences of jellyfish swarms invading fishing grounds and harbours. Evidently, these resilient creatures thrive in those very conditions brought upon by climate change, pollution, habitat degradation and mechanised trawling. Instead of painting the jellyfish as the bad guy, author Lisa-Ann Gershwin celebrates their existence, by taking readers back to the Proterozoic era, when they were the ocean's top predators. Interesting and unusual characteristics about their behaviour are highlighted, giving readers a glimpse into the fascinating and unique creature that is the jellyfish.

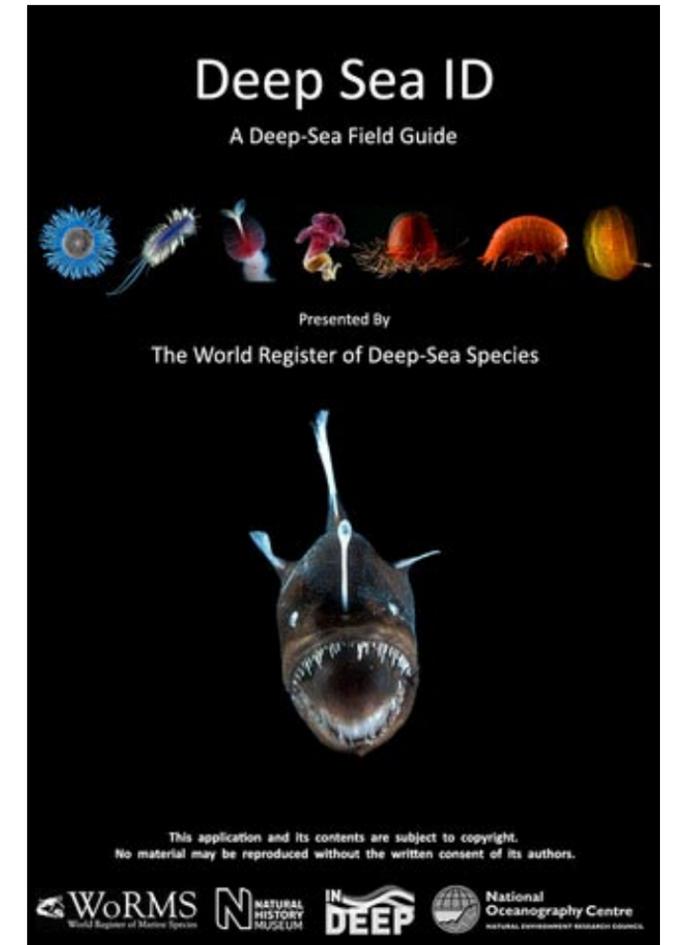
Hardcover: 456 pages  
 Publisher: University Of Chicago Press  
 Publication Date: 7 May 2013  
 ISBN-10: 022602010X  
 ISBN-13: 978-0226020105



## Seaweeds

*Seaweeds: Edible, Available, and Sustainable* by Ole G. Mouritsen. Far from being just the 'grass' on the ocean floor that occasionally washes ashore and causes a mess, seaweed is much, much more than that. For starters, it's an aglae (not a plant) that's been used in many cultures since the prehistoric times. Although this book prominently showcases seaweed as food (in sushi, salads, snacks, soups, dessert, seasoning, drinks, etc), this versatile aglae is also used in construction, glass-making, medicine and even the textile industry. Along the way, the author describes the biology, ecology, cultural history, gastronomy and nutritional value of seaweed, alongside hundreds of illustrations showing the different species of seaweed. With more than 10,000 species and a history dating back at least 500 million years, this book is sure to provide hours of engaging reading.

Hardcover: 304 pages  
 Publisher: University of Chicago Press  
 Publication Date: 5 June 2013  
 ISBN-10: 022604436X  
 ISBN-13: 978-0226044361



## Deep Sea ID app

By the Natural History Museum. With the handy Deep Sea ID app installed in your iPhone, you would have access to the taxonomic data of more than 20,000 deep-sea creatures literally at your fingertips. Its high-resolution photos, together with links to online taxonomic tools, sources and references, are an aid to species identification. Although designed for the scientific community, this free app allows anyone interested in deep-sea creatures to take a peek into this alien world. Get it at [iTunes.apple.com](https://itunes.apple.com).

# marine mammals



## Humpback whales are able teach each other hunting techniques

Scientists believe their results strengthen the case that cetaceans—whales and dolphins—have evolved sophisticated cultural capacities.

A team of researchers, led by the University of St Andrews, has discovered that a new feeding technique has quickly spread to 40 percent of a humpback whale population.

Humpbacks around the world herd shoals of prey by blowing bubbles underwater to produce 'bubble nets'.

The feeding innovation, called 'lobtail feeding', involves hitting the water with the tail before diving to produce the bubble nets. Lobtail feeding was first observed in 1980, after the stocks of her-

ring, previously the main food for the whales, became depleted.

### Cultural transmission

The scientists used a new technique called network-based diffusion analysis to demonstrate that the pattern of spread followed the network of social relationships within the population, showing that the new behaviour had spread through cultural transmission, the same process that underlies the diversity of human culture. ■

SOURCE: SCIENCE



Humpback whale with bubble net

## Evolution of baleen whales and penguins possibly triggered by sea-ice ecosystem

Around 33 million years ago, our planet was quickly cooling, leading to a huge ice sheet covering a formerly sub-tropical Antarctica. Consequently, the marine ecosystem changed, and ocean plankton diversity suddenly collapsed. Only plankton species adapted to temporary sea-ice cover remained, present in large numbers (algal blooms) only when the sea-ice melted in spring and summer.

Marine animals, such as baleen whales and penguins, that fed on these plankton adapted to the change in plankton diversity, according to a new study by an international team of scientists from the Goethe University and the Biodiversity and Climate Research Centre in Frankfurt, Germany. The study, published in the journal *Science*, showed that further adaptation and evolution of baleen whales and penguins were possibly triggered by the development of the sea-ice ecosystem.

The key to the discovery was the tracking of algal blooms of a specific species of dinoflagellates through the examination of sediment samples in drill cores on the ocean floor. "The sudden turnover in the dinoflagellate assemblages indicates clearly that the entire plankton ecosystem of the Antarctic waters had changed," said study co-author Professor Jörg Pross, paleoclimatologist at the Goethe University and the Biodiversity and Climate Research Centre (BiK-F) in Frankfurt, Germany. "Our data suggest that this change may have promoted the evolution of modern baleen whales and penguins." The study findings draw attention to the role of major climate change in rapid biological evolution. ■

SOURCE: SCIENCE / PHYS.ORG

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## 'Morally unacceptable'— Captive dolphin shows banned in India

Dolphins can no longer be kept in captivity for entertainment purposes anywhere in India. In a landmark decision, the country's Ministry of Environment and Forests has forbidden dolphin shows, stating that such practices are "morally unacceptable".

In the ministry's new policy, state governments are advised to reject any proposal for the building of a dolphinarium "that involves import, capture of cetacean species to establish for commercial entertainment, private or public exhibition and interaction purposes whatsoever."

### Stress in captivity

Authorities have recognized that dolphins and other cetaceans do not fair well in captivity. "Confinement in captivity can seriously compromise the welfare and survival of all types of cetaceans by altering their behaviour and causing extreme distress," said the member secretary of the

Central Zoo Authority of India, B.S.Bonal, in the ministry's statement.

In addition, the ministry noted the importance of protecting the endangered species of India such as the Ganges River dolphin and the snubfin dolphin, both of which are protected under the Wild Life Protection Act of 1972 along with all other cetacean species.

"Whereas cetaceans in general are highly intelligent and sensitive, and various scientists who have researched dolphin behavior have suggested that the unusually high intelligence; as compared to other animals means that dolphin should be seen as 'non-human persons' and as such should have their own specific rights and is morally unacceptable to keep them captive for entertainment purpose," said the ministry.

### Praise

Conservationists in India praised the decision. A spokesperson

for the grassroots organization, the Federation of Indian Animal Protection Organization (FIAPO), Puja Mitra called the decision "a huge victory for the dolphins!" FIAPO led the campaign in India to ban dolphinarium in the country, gaining support from local communities at the grassroots level and meeting with key officials of the ministry.

"India has become a beacon of hope for the global movement to protect cetaceans from captivity, and we thank Minister Jayanthi Natarajan for setting the benchmark in animal protection for the world," said Mitra.

Other groups working with FIAPO over the past year to ban dolphin shows include the Born Free Foundation, Global Green Grants Fund, Wildlife Rescue and Rehabilitation and Earth Island Institute's Dolphin Project. Praise for India's action was heard from other parts of the world.

"This is a huge win for dolphins," said Ric O'Barry, director of the U.S.-based Earth Island Institute's Dolphin Project and former dolphin trainer. "Not only has the Indian government spoken out against cruelty, they have contributed to an emerging and vital dialogue about the ways we think about dolphins – as thinking, feeling beings rather than pieces of property to make money off of."

■ SOURCE: ENVIRONMENT NEWS SERVICE

## Navy dolphin uncovers 19th century torpedo

There you are, a Navy dolphin, looking for mines off the coast of San Diego, minding your own business, when suddenly you stumble upon an object on the seafloor that turns out to be a rare 130-year-old torpedo of which only 50 were ever made.

That's what happened to one special dolphin who found one of

filled with 100 pounds (45 kg) of gun cotton, said military officials.

"It was the first torpedo that could be released into the ocean and follow a track," said Christian Harris, operations supervisor for the SSC Pacific Biosciences Division. "Considering that it was made before electricity was provided to U.S. households, it was



STE ELMORE / WIKIPEDIA COMMONS

the first self-propelled torpedoes employed by the U.S. Navy in the 1880s. In a statement, operations supervisor Braden Duryee of the SSC Pacific Biosciences Division said, "Dolphins naturally possess the most sophisticated sonar known to man. They can detect mines and other potentially dangerous objects on the ocean floor that are acoustically difficult targets to detect."

The brass-coated weapon was a so-called Howell torpedo with 132-lb (60 kilogram) flywheel that was spun before launch. With a range of 400 yards, it could reach 25 knots and had a warhead

pretty sophisticated for its time."

Only one other example of this type of torpedo has been found and is currently housed at the Naval Undersea Museum in Keyport, Washington.

While the dolphin's finding shows off its amazing sonar ability, cetaceans are susceptible to injury from high-powered naval sonar employed during military exercises. Last year, Navy officials said that the U.S. military will retire its dolphin program in 2017 and move towards the use of less expensive mine-hunting robots instead. ■

SOURCE: DISCOVERY/LIVE SCIENCE

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NOAA

# turtle tales



Edited by  
Bonnie McKenna

## Sea turtle found that pooped plastic for a month

The turtle was rescued in 2009 after marine biologists at Melbourne Beach in the U.S. state of Florida noticed that it seemed to be having problems digesting food. After dislodging a large piece of plastic from the animal's gastrointestinal tract, the turtle proceeded to defecate 74 foreign objects over the next month. Some of those objects included four balloons, five pieces of string, nine types of soft plastic, four types of hard plastic, a piece of carpet-like material and two large tar balls.

This turtle represents a growing problem for sea turtles around the world. According to a report, about half of all surveyed sea turtles have ingested plastic.

As single-use plastics increase in use and are mindlessly discarded, they gather in the eddying currents of the world's oceans. It is estimated that more than 1 billion single-use plastic bags are given out every day. Though the report estimates that only about 0.2-0.3 percent of plastic production eventually ends up in the ocean, it accumulates at an alarming rate. In the 1960s, less than 1 percent of our waste was plastic, but today it makes up to 80 percent of all waste that accumulates on land, shorelines, the ocean surface or seabed.

"Last year I counted 76 plastic bags in the ocean in just one

minute while standing in the bow of our sea turtle research boat at sea in Indonesia," said Dr Wallace J. Nichols. "The science is becoming crystal clear: sea turtles and plastic pollution don't mix well. Sea turtles have spent the past 100 million years roaming seas free of plastic pollution, and are now sadly the poster animal for impacts of our throw-away society on endangered species."

Plastic debris ensnares other marine mammals like seals, and plastics are commonly discovered in the stomachs of whales, dolphins and fish. Micro-plastics have also been found to be accumulating in mollusks and crustaceans.

In an effort to work on solutions to these problems, the Fifth International Marine Debris Conference is bringing together marine debris researchers from around the world. The conference hopes to heighten global understanding and appreciation of the threats posed by marine debris, highlight recent advances in marine debris research, and provide an opportunity for the development of collaborative solutions to these problems. ■

The green sea turtle below, named Tripod, lost one of her rear flippers because it was caught in a plastic cola-keeper which cut off circulation to the flipper and killed it

## A conservation success story

Green sea turtles have inhabited the Pacific coast of Mexico for millions of years, for the past few decades the turtles have struggled to survive a relentless onslaught of hunting. In the early 1980s, there were still some 25,000 nests found along the coast of Mexico. By the mid-1990s, poaching, fishing nets and habitat destruction cut the number of nesting females to less than 500.

A doctoral student named

animal had been tracked swimming across an ocean.

"These turtles are big, strong and wild—yet gentle," said Nichols. "And you can get close to them and interact with them. There aren't too many creatures that big that you can do that with in the wild, and on their own terms. My goal was to share that sense of wonder, not to preach."

Nichols invited dozens of turtle-hunting fishermen to a meeting to talk about their knowledge of local turtles and the possibility of their extinction. In time, many of the poachers agreed to catch and eat fewer turtles—which are traditionally prized for their red-meat-like flesh—and soon began working with Nichols to monitor local turtle populations.

Twenty years later, Grupo Tortuguero, the grassroots network that Nichols helped found, is active in 50 coastal communities. Hundreds of local volunteers, many former poachers, work to protect and promote an appreciation for and pride in these gentle animals.

This year, there were some 15,000 green turtle nests on the beaches of southern Mexico. ■



ROY NISWANGER/MARINE PHOTOBANK

Wallace J. Nichols proposed studying the biology and conservation of sea turtles in northwestern Mexico for his thesis, but he was told that cultural inertia was too great to overcome. Undeterred, Nichols and a colleague travelled Baja California to study five species of sea turtle that congregate on both sides of the peninsula's 1,900 miles of coastline to feed on crab, jellyfish, sea sponges and algae.

With the help of a local fisherman and a Mexican biologist, Nichols attached a transmitter to a loggerhead's shell. The turtle, named Adelita after the fisherman's daughter, swam 7,000 miles from Baja to nesting grounds in Japan, marking the first time any

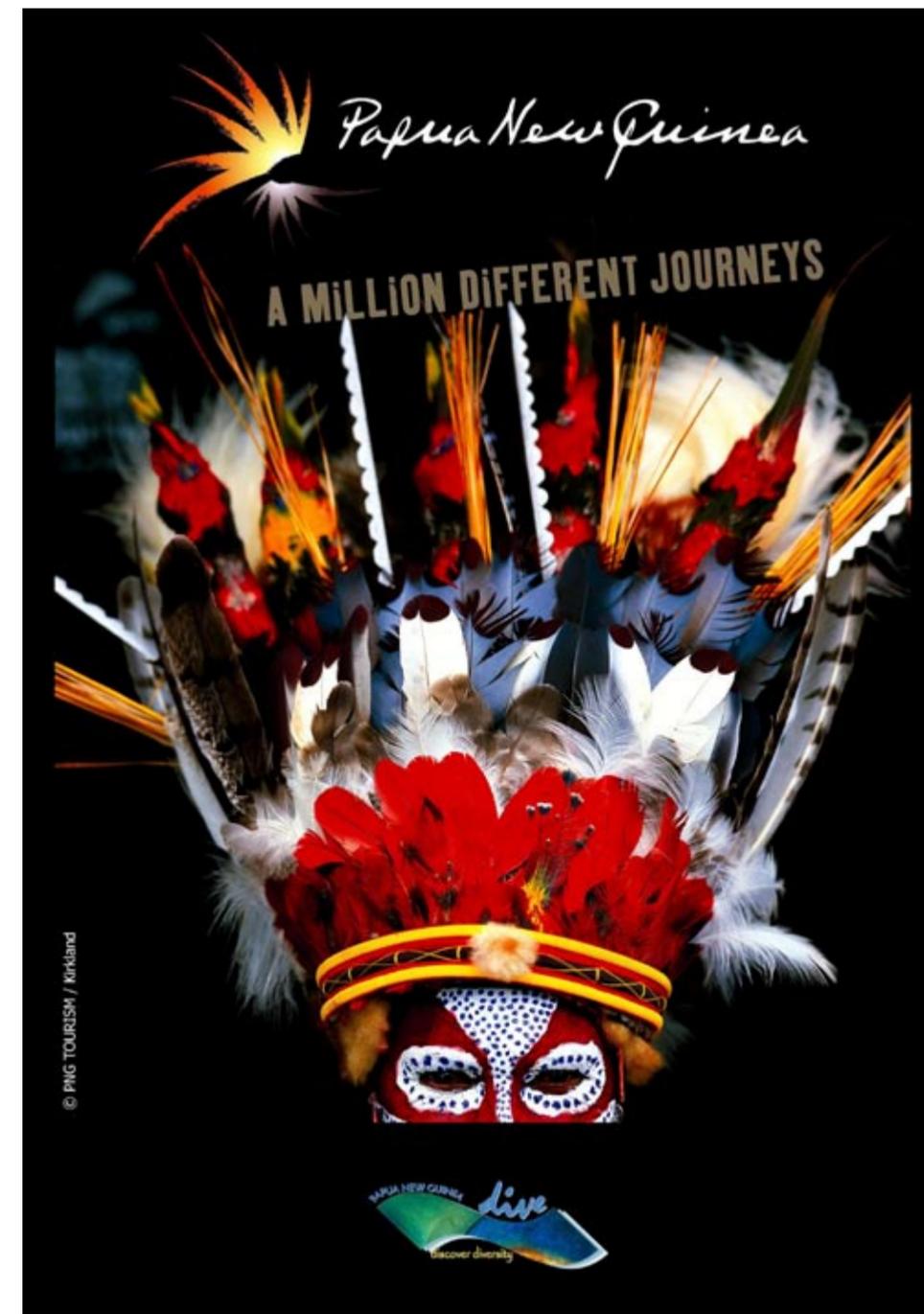
## Fishery rule could benefit marine turtles

The leatherback sea turtle's wide ranging migratory patterns overlap those of other severely threatened and depleted ocean wildlife. Surface longlines fishing for tuna and swordfish also catch and kill more than 80 other marine species. More than half of the catch is thrown back, and the vast majority of the discarded catch is dead.

In an effort to protect bluefin tuna spawning grounds in the Gulf of Mexico, scientists are working with fishermen to determine if two selective fishing methods can provide an alternative to longlines. To date, research indicates that 87 to 90 percent of the catch on the alternative fishing gear is comprised of targeted tuna and

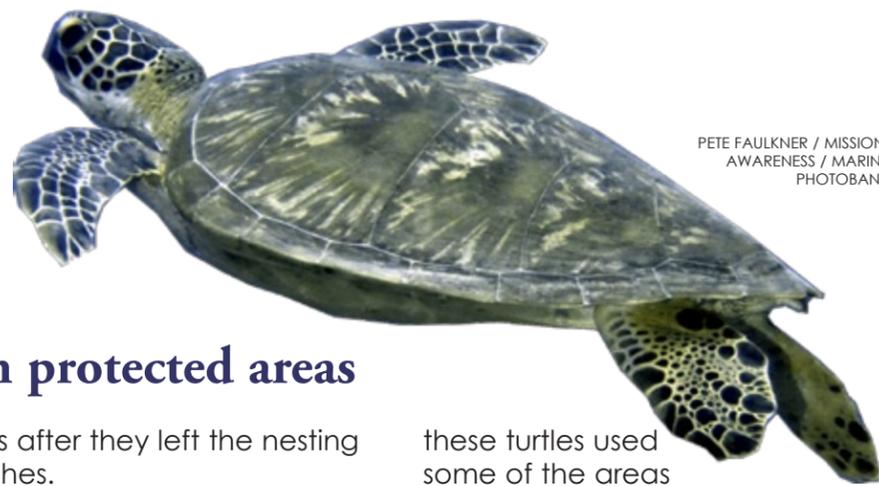
swordfish. Oil spill money made available by BP could help pay to transition Gulf surface longline fishing gear.

Marine turtles stand to benefit greatly, if these new measures are implemented. The rule would eliminate, annually, 169 harmful interactions with endangered leatherback and loggerhead sea turtles. ■



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PETE FAULKNER / MISSION: AWARENESS / MARINE PHOTOBANK

## Sea turtles benefiting from protected areas

In the Dry Tortugas National Park of the U.S. state of Florida, nesting green sea turtles are benefiting from marine protected areas by using habitats found within their boundaries. The forays of green turtles, listed as endangered in Florida and threatened throughout their range, after nesting has long remained a mystery.

The U.S. Geological Survey researchers confirmed the turtles' use of the protected area by tracking the turtles with satellite tags and analyzing their move-

ments after they left the nesting beaches.

"Our goal was to better understand what types of habitats they use at sea and whether they were in fact putting these designated areas to use. This study not only shows managers that these designated protected areas are already being used by turtles, but provides insight into the types of habitat they use most," said Kristen Hart a research ecologist for the U.S. Geological Survey.

"We are thrilled to find that

these turtles used some of the areas already under 'protected' status. The ultimate goal is to help managers understand where these endangered turtles spend their time both during the breeding period and when they are at feeding areas. Given the worldwide declines in seagrasses—one of the most important habitats they rely on for food—has already been documented, this type of data is critical for managers," said Hart. ■



## Logs block leatherback turtles nesting in Gabon

Abandoned logs on the beaches of Gabon are keeping leatherback turtles from nesting, according to a study in the journal *Biological Conservation*. Timber is big business in Gabon. As the logs move down river,

many get loose and end up on the beaches trapping turtles.

Despite log exports being banned, the ban has not improved the turtles' situation. It is estimated that logs block 17 percent of the turtles' move-

ments. The journal stated that the problem is persistent and has the potential to remain unless remedial action is taken to remove the logs. ■

## Mediterranean Association to Save the Sea Turtles celebrates its 25th anniversary

It all began in 1983 when Lily Venizelos realized that sea turtles were nesting in Laganas Bay on the island of Zakynthos in Greece. Five years later, she officially founded MEDASSET, and now it is a fully-fledged and highly professional U.K. registered charity and an independent NGO registered in Greece.

Since its inception, MEDASSET remains the only organization working exclusively on sea turtle conservation throughout the Mediterranean.

Venizelos surveyed almost 8,000km of the Mediterranean coastline, identifying new nesting sites and confirming the absence

of turtles in key areas; MEDASSET has made a major contribution to the legal framework that protects sea turtles in Greece, Egypt and Albania.

In May 2012, MEDASSET joined forces with OCEAN2012, a coalition of more than 170 European NGOs to ensure the E.U. Common Fisheries Policy (CFP) stops overfishing, ends destructive fishing practices and ensures the equitable use of fish stock for local communities. By-catch kills an estimated 44,000 turtles every year in the Mediterranean.

Prior to February 2013, MEDASSET delivered numerous letters prior to critical votes on

the CFP reform to the Greek and Cypriot fisheries and members of the European Parliament asking for the right decisions to be taken to help populate our seas.

The campaign peaked as members voted for the reform. By an overwhelming majority, amendments were passed to ban discards, restore fish stocks by 2020, and apply strict fishing capacity assessments.

All of this is good news for fish, small-scale fishermen, sea turtles and marine biodiversity. The next step by MEDASSET is to make sure the European Council does not water down the reform. ■

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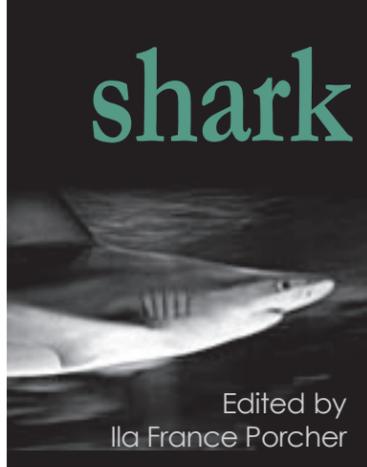
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Edited by  
Ila France Porcher

## What are sharks doing when no one is looking? —On the Ethology of Reef Sharks

Text and images by Ila France Porcher

**In my last article, *When Sharks Really Attack (X-RAY MAG #52)*, I described an unusual series of events indicating that sharks experience subjective states, or emotions. This follow-up piece provides further information about the reef sharks I studied closely underwater for seven years.**

A difficulty in obtaining information about the natural behaviour of wild animals is that detailed observations of the activities of different individuals is necessary over long periods of time. This is especially hard to achieve with sharks.

Fortunately, in the wide lagoon near my home in French Polynesia, which averages a depth of two meters, it was possible to observe the sharks easily for long periods and collect a large amount of data on their movements and behaviour. The blackfin reef shark, (*Carcharhinus melanopterus*) was especially easy to observe. Over the years, I identified six hundred individuals and could recognize three hundred on sight.

Ethology is a field of zoology, and one of its major principles is to “know your animal” by observing its behaviour

over an extended period of time. Such observations take so long in today's rapid pace of science that it's far easier to place tags on them. There are excellent advantages in accomplishing studies of numerous animals by such means, and the field of behavioural science can well use such information. Its popularity is without question, but it cannot often

explain, except in the broadest sense, why animals do what they do, since individuals often don't do what others around them do. That's why the work of ethologists will always be valuable.

Following the ideas of Konrad Lorenz, Nikolaas Tinbergen, Arthur Myrberg, Donald Griffin, and others, I identified the sharks by drawing the markings on both

sides of the dorsal fin, and found that observing them as individuals revealed a whole new dimension of behaviour. One of the most surprising things was the degree and variety of individual differences that they displayed.

### Individuality

Each shark's behaviour was unique and

seemed flexible from day to day. Not only was their behaviour towards me unique, but so was their use of time and their patterns of roaming. Sometimes a shark passed the same coral formation at almost exactly the same time each evening for several nights in a row, then disappeared from the area for a year. Sometimes, day after day, a shark could





be found in exactly the same place in her home range at the same time, then the following day she was roaming on the outer slope of the reef at that time. There were some days that all the females left the study area, and others when it was filled with visiting neighbors.

## Study

Once a week I brought them some scraps from local fishers so that I could identify the sharks in the area that evening, and I visited at random times to observe them and to accompany them when possible while they roamed. Eventually, they became so used to my presence that they treated me as they would another shark. (One cannot expect an animal to treat one in a brand new way because one is a different species). Thus I was able to witness their intimate social and emotional behaviour as if no one was watching them. For all the years I knew them, I kept seeing new behaviour patterns, some which would have been unbelievable to me in the beginning.

The study area was seldom visited by other people, so observations could be obtained without disturbance, and the sharks were relatively unaffected by other human encounters.

## Home range

The lagoon was the domain of the female blackfin reef sharks, each of whom spent much of her time in a favoured region called a home range; the pups were born and matured in those sheltered waters. Beside the resident females, others whose home ranges were farther away came from time to time, and there were many juveniles. The youngest were two to three years old, since they remain in hiding until

they grow enough to mix with the rest of the community. While most of the males lived in the ocean on the outer slope of the barrier reef, a very few ranged through the lagoon. These male sharks were smaller than the females, lithe and muscular, most being less than four feet long. They seemed less attached to a home range and roamed much farther afield during their daily travels.

In the mating season, bands of males from the ocean would arrive at nightfall, to the excitement of the females. The largest females were close to six feet in length, and maternally heavy with a more rounded silhouette.

The residents of the study area soon recognized the sound of my kayak crossing into the lagoon from the adjacent bay, and anchoring at my usual place, and when I slid underwater, they were waiting, no matter what time I came. But the one I had dubbed "Bratworst" would always arrive two minutes after me. This began to puzzle me so much that I decided to investigate and anchored and slid underwater without a pause on my next visit. Not a shark was visible. So I drifted silently with the current and found Bratworst lurking behind a coral, just beyond visual range of my boat. It was my first clue that sharks listen from beyond the visual range, and come when they decide to.

## Senses

I had learned years before, when first observing them and learning to move swiftly and silently, that sharks can hear a person swimming long before he or she comes within visual range. The shark usually vanishes before the person sees that it is there, but the possibility that members of such an ancient line of animals could use the limit of visibility as a



veil behind which to conceal themselves, was new.

I often observed sharks following each other beyond the visual range. The shark I was with would catch up to the one she was following, and swim nose to tail with her or side by side. Then, after resuming her arcing path for a time, she often caught up to another shark and briefly swam beside her. The sharks generally roamed in circular or oval paths of various diameters which crossed at the centre and formed rough figure of eights or cloverleaves. Such patterns likely brought them repeatedly into contact

with each other's scent trail, allowing them to keep track of each other while travelling in circling paths, out of visual range of each other much of the time .

Curious sharks also followed me, always remaining hidden behind the veiling light except for an occasional pass into view. Apparently they listened and used their lateral line sense to monitor my actions, instead of eye-sight. I began regularly checking to see who was following me by stopping and drifting with the current, whereon the sneaky sharks behind soon came into view.

## Shark friendship

These sharks knew each other as individuals, and it was soon clear that they had preferred companions with whom they liked to travel. Some companionships were so strong that I never found one shark without the other. Some friends separated on occasion and travelled with different companions for a time, reappearing months later together again, while some sharks always travelled alone.

At times groups of sharks, all from a particular region, and often accompanied by specific males,

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travelled together. They moved in loose contact along the fringe lagoons of the island, and were joined temporarily by local residents as they went. But their tendency to roam out of visual range of each other complicated the problem of figuring out who was with who.

## Kimberley and Twilight

One of the elderly female visitors was nearly black, with two pure white markings symmetrically placed, one on each side of her head. It looked as if someone had stuck two large snowflakes on her. Arriving always at dusk, she was a dramatic sight with the twin white points

glowing bright. I called her "Kimberley".

She remained in the area for an entire lunar cycle, and when she left, another very similar shark appeared. Not only was the patterning of their colour lines and dorsal fins alike—the opposite sides were nearly identical—but this shark, too, had pale markings placed precisely the same way on her head. She also arrived just at nightfall, and I called her "Twilight". Since none of the other sharks had such white markings, I speculated that the two were sisters.

It was months before either of them returned to the area, but there came an evening when the twin snowflakes

approached again through the gloom. Kimberley glided in, and the following week, I saw Twilight. For three years I watched these sharks come and go every few months, only occasionally together. Was it chance? Or could there really be an association between them?

One night it was so late that the sharks were just movements in the darkness when I put the anchor in the boat, and began to drift with it. But after only five metres, Kimberley appeared in the gloom. I waited. A minute passed. Then Twilight approached, following Kimberley's trail. The two sharks were not within visual range.

Trailing the kayak, I finned toward Twilight and was able to approach and swim with her. She went toward the feeding site but turned to pass down current from it. Had I been at my usual location, she would not have been visible. Then she turned back.

Kimberley appeared, equidistant on my other side. She had apparently already crossed the site and circled back. The two immense sharks curved onward as though following arcs of the same circle. They met in front of me, passing close by each other. I took in every detail, but saw no signal from either of them, and wondered whether something more was exchanged between the old friends than what a human eye could discern.

Twilight languidly cruised back and forth in large figure of eight patterns. Time after time, she overtook another female shark, apparently by pursuing her trail of scent. Had she been targeting the other shark's vibrations, it was unlikely that we would always have joined her by coming up behind her. Each time, the two big females passed close beside each other, and continued on their

Portrait of a shark name Martha, by Ila France Porcher (right); The shark named Kimberly (lower left)



separate ways. When I left, the visitors were still socializing with the residents down current from the feeding site. Often they came only to visit, and not to eat.

Gleefully concluding that I had been right—that there was a companionship between the two sharks after all—I left. Kimberley and Twilight arrived swimming together on their next three visits, months apart, and on several more occasions before Kimberley died, confirming what had taken years to verify.

## Visual range

There were other ways in which the various species of sharks on the reef used the limits of visibility. Their pattern of approach, for example, generally involved just a single pass into visible range, often repeated within a few minutes. This pattern is so common that it is easily seen on any shark dive. Though I initially analysed the pattern in reef sharks, it was clear to see when I dove with tiger sharks, too. Shyer individuals intermittently passed at the limit of the

visual range, never approaching.

If the shark was very interested or curious, it would come closer on each pass until it swam straight in, but shy sharks would not approach at all unless there was a group present, and if anything was different about my routine, even the resident sharks would retreat beyond their curtain of blue, only passing into view from time to time. This was especially problematic when the BBC came to film them for Shark Week. Mike DeGruy didn't believe me at first when I assured him, as we surveyed the empty coral landscape, that 30 sharks were hiding just out of sight.

Whenever a second person came with me, the sharks remained behind the visual limit for up to ten minutes before approaching. Sometimes when they appeared they approached in long lines, led by the boldest ones, and went straight to the stranger. This reaction never happened when I was alone, and demonstrated the sharks' ability to recognize changes in routine, and to



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Illustration of author's interaction with a shark named Madonna, by Ila France Porcher

make rapid decisions to stay or leave depending on unfolding events. It is closely associated with learning, which has been experimentally shown many times in elasmobranchs.

## Awareness

Sharks are also aware of the direction a person is facing and may respond instantaneously when the person of whom they are nervous puts his or her head above the surface, or even looks the other way; a common move is to approach from behind.

Once I was swimming through the study area with my step-son when he climbed on a coral to look around above the surface. The shark accompanying us instantly glided over to him and, unseen by the boy, sniffed his legs.

The sharks indicated their awareness of whether the person was able to see them or not in many ways, and used this awareness to their advantage. Other species of reef sharks in the community, including white-tip reef sharks (*Triaenodon obesus*), and sicklefin lemon sharks (*Negaprion acutidens*) displayed the same awareness and general behaviour with regards to hiding in the veiling light. They also would often approach from behind, when a person was looking the other way, or had raised his or her head above the surface.

Thus the best thing to do when with sharks, is to face them eye to eye, and they will respect you. Its useful to look around often too!

## Sharks party

When there were many visitors in the study area, there was much excitement and socializing. The most dramatic

feeding sessions that I mentioned in my former article, *When Sharks Really Attack*, occurred when there were many visitors and the moon was full. Since their roaming correlated with the lunar phase, I began to think of the thrilled shark tornadoes that developed as the full moon rose as "partying behaviour."

An old lady shark who normally never accelerated would suddenly shoot vertical, shake off her remora, and streak away out of sight so fast that the eye could scarcely follow her. Then she would rocket through the scene again, with many others shooting with her out of view in the opposite direction.

The resident sharks were always more excited when the moon was full, especially when visitors had joined them. The incidents described in my former article, when the sharks unanimously slammed the boat and leaped out of the water to snap at whatever fish-scrap they could reach, happened at such times. Sharks of this species do not naturally put their heads above the surface to eat nor to look around, so this was a completely new foraging behaviour. It was initiated by specific individuals, and was instantaneously adopted by the others present. This finding of a new foraging technique occurred in two different locations, years apart, with different groups of sharks, and presents examples of social learning.

## Lunar connection

That sharks timed their travels according to the lunar phase was clear to see when watching them. For example, two elderly female sharks appeared in my study area during the period of the dark of the moon at the end of April four years in a row, staying in the region about two



weeks, until the moon waxed bright, when they left. They came at no other time. Presumably they chose the study area in which to wait through the dark period, and left when they would have two weeks of bright nights to facilitate their travels.

I observed their visits each year until the sharks were finned in 2004, after which no elderly sharks ever appeared. One visiting male's first four visits, though months apart, occurred precisely at sunset, four days before the dark of the moon. Visitors tended to stay in the region for half or a whole lunar cycle, and residents often left during the period of the full moon, returning in ten days to

two weeks as the moon waned and the light at night faded.

Most birthing and mating events also took place during the period of the full moon. The resident females left their ranges about a week before, and generally returned about two weeks later, when it was waning. Perhaps it was because of the need to travel, sometimes many kilometers or even to another island (Mourier, J. & Planes, S. 2013), that such a high percentage of births took place during the full moon. Since the tides on the islands are solar, it seems that the light at night is the important factor—sharks use both sources of planetary light for travelling, not just the sun.

When the sharks I had come to know so well were finned by a company in Singapore, I wrote down the story of what it was like to get to know them, what they were like, and what happened, in an effort to get their story out of French Polynesia. The name of the book is *My Sunset Rendezvous: Crisis in Tahiti*. ■

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(File photo) A great white shark at Isla Guadalupe, Mexico

## Pacific Great White Shark not endangered NOAA finds

**Northeastern Pacific Ocean population of great white sharks does not warrant listing under the Endangered Species Act, NOAA announced Friday.**

Scientists of the U.S. National Oceanic and Atmospheric Administration (NOAA) concluded that the white shark population is a distinct genetic group with a low to very low risk of extinction now and in the foreseeable future.

NOAA had been investigating the great white population since last year, when the environmental groups Oceana, Shark Stewards and the Center for Biological Diversity filed a petition calling for endangered species protection.

The petitioners were reacting to the first ever census of great whites, which was conducted by University of California-Davis and Stanford University researchers, and published in the journal *Biology Letters* in 2011. The cen-

sus estimated that only 219 adult and sub-adult great whites lived off the Central California coast, and perhaps double that many were in the entire northeastern Pacific Ocean, including Southern California.

A joint statement from Oceana, Center for Biological Diversity, Shark Stewards and WildEarth Guardians said federal authorities ignored studies that listed less than 700 sharks off the California coast.

"Our team felt that there were more than 200 mature females alone, an indication of a total population of at least 3,000," countered Heidi Dewar, a fisheries research biologist at NOAA. NOAA's analysis, which will be made public Monday, was based

on a comprehensive review of threats to the population, direct and indirect indicators of abundance trends and analysis of fisheries by catch in the United States and Mexico, Dewar said.

Margaret Spring, vice president at Monterey Bay Aquarium for conservation and science, said in a news release the organization appreciated the "thorough review" by the National Oceanic and Atmospheric Administration.

"We are fully committed to supporting rigorous science, public education efforts and ocean policy reform," she wrote, "to ensure that great white sharks do not become more vulnerable in the future." ■ SOURCE: NOAA



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