Sharks sense prey in surprising ways during pioneering study

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Nose plugs were used to block the sense of smell on a blacktip shark in the study. Credit: Mote Marine Laboratory

(Phys.org) —A team of scientists have unmasked the intricacies of how sharks hunt prey—from the first whiff to the final chomp —in a new study about shark senses that was supported by the National Science Foundation and published in the peer-reviewed journal *PLOS ONE.*

The study, led by scientists from the University of South Florida, Mote Marine Laboratory and Boston University, is the first to show how vision, touch, smell and other senses combine to guide a detailed series of animal behaviors from start to finish. Results show that sharks with different lifestyles may favor different senses, and they can sometimes switch when their preferred senses are blocked. That's hopeful news for sharks trying to find food in changing and sometimes degraded environments.

"This is undoubtedly the most comprehensive multi-sensory study on any shark, skate or ray," said Philip Motta, a USF biology professor and internationally-recognized shark expert who co-authored this study.

"Perhaps the most revealing thing to me was the startling difference in how these different shark species utilize and switch between the various senses as they hunt and capture their prey. Most references to shark hunting overemphasize and oversimplify the use of one or two senses; this study reveals the complexity and differences that are related to the sharks' ecology and habitats."

Understanding how sharks sense and interact with their environment is vital for sustaining populations of these marine predators, which support the health of oceans around the world. Overfishing is the greatest known threat, but pollution and other environmental changes may affect the natural signals that sharks need for hunting and other key behaviors. In addition, understanding the senses of sharks and other marine life could inspire new designs for underwater robotics. However, before shark senses can teach us anything, scientists must gain a basic understanding of how they work.

Past studies have suggested that sharks sense the drifting smell of distant prey, swim upstream toward it using their lateral lines—the touch-sensitive systems that feel water movement—and then at closer ranges they seem to aim and strike using vision, lateral line or electroreception—a special sense that sharks and related fish use to detect electric fields from living prey. However, no study has shown how these senses work together in every step of hunting, until now.

"Our findings may surprise a lot of people," said Jayne Gardiner, lead author of the study and a Postdoctoral Fellow at Mote whose thesis at USF included the current study. "The general public often hears that sharks are all about the smell of prey, that they're like big swimming noses. In the scientific community it has been suggested that some sharks, like blacktips, are strongly visual feeders. But in this study, what impressed us most was not one particular sense, but the sharks' ability to switch between multiple senses and the flexibility of their behavior."

The researchers placed blacktip, bonnethead and nurse sharks—three species found along Florida's coast that differ in body structure, hunting strategy and habitat—into a large, specially designed tank where the water flowed straight toward them. The researchers dangled a prey fish or shrimp at the opposite end of the tank, released a hungry shark and tracked the shark's movements towards the prey.

Next, they made the hunt more challenging: They temporarily blocked the sharks' senses one by one using eye coverings, nose plugs to block smell, antibiotics to interfere with their lateral lines that detect water motion and electrically insulating materials to cover the electrosensory pores on their snouts.

Then the researchers took high-speed video—lots of it.

"We had hundreds of video clips to sort through, and we had to get just the right angle to see when the shark was capturing the prey," Gardiner said.

The effort was worth it. Gardiner and her team reported some striking results, including:

Nurse sharks did not recognize their prey if their noses were blocked, but the blacktips and bonnetheads did. Smell may be required for nurse sharks to identify prey because they feed in the dark and often suck hidden prey out of rock crevices. The other two species, which scoop up crustaceans in daytime (bonnetheads) or chase fish especially at dawn and dusk (blacktips), could still recognize prey without their sense of smell—once they got close enough to see it.

When the researchers blocked both vision and lateral line, blacktip and bonnethead sharks could not follow the odor trail to locate prey, but nurse sharks could. Nurse sharks tend to touch the bottom with their pectoral fins—likely another way to feel which direction the water is moving, and thus which direction they should proceed. However, hunting this way was slow going.

When the sharks' vision was blocked, removing a key sense for aiming at prey from long distances, they could compensate by lining up their strikes, albeit at closer range, using the lateral line, which can sense water movements from struggling prey.

During normal feeding in all three species, the prey's electric field triggered opening their mouths at very close range. However, electricity alone was not enough: Blocking vision and lateral line prevented sharks from striking, even when they were close enough to sense the prey's electric field.

With electroreception blocked, sharks usually failed to capture prey. However, blacktip and nurse sharks sometimes opened their mouths at the right time if their jaws touched prey, whereas touch did not help bonnetheads. Scientists suspect that bonnetheads rely strongly on electroreception because their wide heads allow them to have the special pores that sense electric fields spread across a wider area.

"We sought to discover how sharks use their highly evolved senses to hunt and locate prey, knowing it involved more than just a good sense of smell," said Bob Hueter, Director of Mote's Center for Shark Research and co-author of the current study. "What we found was amazing, not only in how the various senses mesh together but also how one shark species can vary from another. Not all sharks behave alike."

In general, the results provide the most detailed play-by-play description of shark hunting behavior to date, from long-range tracking of smells and swimming upstream using the lateral line to orienting and striking using vision, lateral line and finally electroreception.

The shark study tank at Mote Marine Laboratory.

"This is landmark work," said co-author Jelle Atema, a professor of biology at Boston University and Adjunct Scientist at Woods Hole

Oceanographic Institution who worked with Gardiner on pioneering studies of shark senses that were precursors to the current study.

"Back in 1985, world experts in underwater animal senses met at Mote, and at that time we emphasized that sensory studies were focusing on one animal at a time, one sense at a time, and we needed to start combining this information. Now we have."

While the results do not focus on shark-and-human interactions, they do highlight that some shark-safety measures, like specially patterned wetsuits meant to provide visual camouflage or electrical deterrents that target the sharks' electrosensory system—each focusing on one sense at a time—may not be enough to change the rates of shark incidents, Gardiner said.

"This also could help explain why most shark 'repellents' may work for a short time but are eventually overcome by persistent sharks," added Hueter.Regardless, shark-and-human interactions are extremely rare because sharks generally do not seek out humans.

The results could also inform future studies with other marine species. According to the paper, "Sharks (…) are not unique in their sensory guidance of hunting: They exploit information fields available to all marine species. Thus, the results may be seen as a general blueprint for underwater hunting, modifiable by habitat and by the behavioral specializations of many different aquatic animals from lobsters to whales."

Understanding the full implications for sharks or any other species in the wild will take much more research, but Gardiner believes the current results bode well.

"I think the sharks' abilities to switch between different senses may make them more resilient in the wild. They may be more flexible and better adapted to deal with environmental changes – but not all human impacts. Overfishing is still overfishing," Gardiner said.

More information: Gardiner JM, Atema J, Hueter RE, Motta PJ (2014) "Multisensory Integration and Behavioral Plasticity in Sharks from Different Ecological Niches." *PLoS ONE* 9(4): e93036. DOI: 10.1371/journal.pone.0093036

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