Yes, size matters

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Looking at traits instead of species opens the door to new fundamental understanding and the capability to predict how life in the Ocean responds to changes. Photo Line Reeh/DTU Aqua.

Why do whales use echolocation when bacteria do not? Because body size determines available sensing modes, argue researchers from Center for Ocean Life

Size is a key parameter to characterize many biological processes in marine environments, such as metabolic rates, feeding and mating strategies of animals. A new study, published in the *Proceedings of the*

Royal Society of London B on September 16th 2015, shows that also the available sensory modes for ocean life is structured by size.

Survival in aquatic environments requires organisms to have effective means of collecting information from the surroundings through various senses to find food and a mate – and to avoid being eaten. Information is collected through the senses of smell, touch, vision, hearing and echolocation, among others. Why do most organisms predominantly use only some of the available senses?

In nature, the smallest organisms, like bacteria, depend heavily on chemical signals, while for larger animals, like copepods, sensing of fluid flows ("touch") becomes important, too. For even larger organisms, vision (for crustaceans and fish), hearing (fish) and echolocation (toothed whales) become increasingly relevant sensory modes.

"When confronted with the diversity of marine life it seems plausible to ask - Why don't bacteria have eyes? Or why do fish not echolocate? We wanted to see if we could find and understand a pattern on the grounds of physiology and physics, which are the two basic constraints on the workings of any organism," says one of the authors behind the paper, researcher Erik A Martens, formerly postdoctoral researcher with the Center for Ocean life at DTU Aqua, now assistant professor at the University of Copenhagen.

To explore this, Erik A. Martens, physicist Navish Wadhwa and colleagues from the Center for Ocean Life at DTU Aqua analyzed the underwater physics of various sensory systems - smelling, touch, vision, hearing, and echolocation - to find the limits to body size where these senses can and cannot function. An example is the physical size of an eye which cannot be any smaller than its photoreceptive units based on opsin molecules allow. And the answer was clear.

The analysis showed that size matters very much for how marine organisms sense their environment. Body size determines available sensing modes, and thereby acts as a major structuring factor of aquatic life.

"It all comes down to physics and physiology. Although many of our theoretical models are only rough estimates, they work surprisingly well in capturing the reality of nature. That knowledge may help towards developing better ecological models of the marine environment," explains co-author Navish Wadhwa, DTU Physics and Center for Ocean life.

The size-based approach is one example of the current strong trend towards "trait-based" approaches in biology. Rather than employing the concept of species or functional groups, the idea is to use a trait-based approach where individual organisms are characterized by a few essential traits that describe the ensemble properties of the many species.

Such an approach is an illustration of the gains to be had by combining different fields, here ecology, fluid mechanics, optics, life-history theory etc. involving a close collaboration between biologists and physicists, argues co-author of the paper and deputy director of Center for Ocean Life, DTU Aqua Ken Haste Andersen:

"Looking at traits instead of species opens the door to new fundamental understanding and the capability to predict how life in the Ocean responds to changes. One such master trait that can be used to describe and organize the complexity of life in the oceans appears to be body size ."

More information: "Size Structures Sensory Hierarchy in Ocean Life," *Proc. R. Soc. B* 2015 282 20151346; DOI: 10.1098/rspb.2015.1346