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Evaluating Seasonal Changes in Body Condition for Spotted, Ringed, and Bearded Seals

Arctic seals must manage considerable seasonal changes in sea ice coverage, air and water temperatures, photoperiod, and prey availability. These species utilize blubber for onboard energy storage, thermoregulation, streamlining, and buoyancy, and this insulating layer changes in thickness and composition throughout the year. Specifically, seals rely on blubber as a critical energy reserve during physiologically taxing life-history stages such as breeding, lactation, and molt. Blubber thickness, along with complementary morphometric measures, can be used to assess overall body condition in seals. We used a modified truncated cones method to track within-individual, fine-scale changes in the body condition of three species of Arctic seal. Our study animals included 4 spotted seals (*Phoca largha*), 3 ringed seals (*Pusa hispida*), and 1 bearded seal (*Erignathus barbatus*) trained to participate in research procedures at two facilities in California and Alaska. We used a portable ultrasound machine to measure blubber thickness at 12 sites along the length of each animal. We used photogrammetric methods to measure standard length, curvilinear length, and body heights using scaled photographs. In addition, we collected direct measures of body length, girth, and mass. Ultrasound, photogrammetric, and direct morphometric data were collected weekly for a minimum of one year. Using a modified truncated cones method, seals were modeled as a series of consecutive cones in which the inner core represented lean mass, and the outer layer represented blubber mass. Separating lean mass and growth from dynamic changes in overall body condition enabled assessment of critical periods when seals are most reliant on blubber energy reserves.

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Thermal impacts of body colorization of marine animals on their skin friction drag

There is an increasing need for doing research in drag reduction and performance enhancement techniques. Since the nature has developed processes, materials, and the functions to increase its efficiency, it has the best answers when we seek to improve or optimize a system. One of the sources for inspiring the drag-reduction methods and performance enhancement is biological aquatic systems which can be studied for their desirable properties. One of the methods in drag reduction applied by warm-bodied aquatics, such as marine mammals, scombrid fishes, and sharks is boundary layer heating. These organisms have the capacity to use heat conducted from the body surface to decrease water viscosity around their body and consequently reduce the drag. In this work, a new factor which is affecting the boundary layer of some aquatics and subsequently their skin drag reduction will be studied. The thermal effects of body color of marine organisms will be investigated in some species, such as whales, manta rays, dolphins, penguins, sharks, seals, and sailfish that have black color at the top and white color at the bottom sides of their respective bodies. Considering the marine and water characteristics of the mentioned species, a thermal analysis will be performed in this study, when these aquatic animals are in motion under the water. The surrounding fluxes including the water flux and the sun irradiation inside the water are considered in an energy balance to determine the skin temperature of both sides of the organisms' body. Applying the Blasius solution and computational fluid dynamics methods for heated boundary layers, it will be shown, that the black color on the top and the white color on the bottom side of the bodies of these marine organisms is very efficient in terms of skin drag reduction.

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Gaining Focus: Using RNAi to Understand How T. marmoratus Larval Eyes Maintain Focus

Visual systems are complex and require that all pieces work together to form clear images. The refractive power of the lens is fundamentally important for any eye to maintain correct focusing. During growth, all parts of the eye need to coordinate to maintain focus. Previous studies have thoroughly examined how vertebrates can preserve this property during their growth, but there are few studies which attempt to answer the question in invertebrates. Unlike vertebrates which grow gradually, insects must undergo ecdysis—shed their outer layer, including their lenses. This presents a unique evolutionary challenge to overcome: how do you maintain correct focus with rapid eye growth? An excellent model for eye development are Thermonectus marmoratus larvae which have exceptional eyes that use a bifocal lens to focus images on two retinas. These larvae undergo rapid growth between their 2nd and 3rd larval stages and substantially reform their lenses to accommodate this growth. The cuticular protein Lens3 is a major contributor to the lens. In this project we use RNAi to knock down Lens3 expression and to investigate if reduction of this major lens protein leads to refractive errors, or if T. marmoratus eye development contains compensatory mechanisms that allow correct focus to be maintained. Knockdowns can be measured using a customized ophthalmoscope to determine focusing abilities. This study will provide insights towards the question of whether invertebrates use active or passive regulation to maintain focus.

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A novel, automated approach to electroretinography

Understanding the physiological limits of an animal's visual system is an important part of studying its visual ecology. Without first determining what an animal is physiologically capable of sensing, it is difficult to ascertain what visual information in its environment could have behavioral significance. An effective way to assess the physiology of visual systems is via direct recording of the electrical activity of photoreceptors using a technique known as electroretinography (ERG). But accurate ERG can be time and labor intensive, often involving manual adjustment of the wavelength and intensity of light stimuli and real-time comparison of physiological responses to inform those adjustments. Furthermore, because stimulus adjustment often involves its own skillset, ERG can require expertise beyond that necessary for the electrophysiological preparation itself. To improve both the efficiency and accessibility of ERG, we designed a highly automated system for both stimulus presentation and data acquisition. Rather than relying on manual adjustment of stimuli and real-time comparison of response, our system automatically adjusts the intensity of all light stimuli to specified photon flux. In addition, light control can be achieved through a series of prompts, allowing users to set up and run automated trials after answering a set of basic questions about the experiment. Here we test this novel system's ability to accurately assess spectral sensitivity in the well characterized visual system of the crayfish using both existing magnitude of response and novel temporal acuity based techniques, where higher magnitude of response and temporal acuity denote greater sensitivity. Using this system, we find that we are able to acquire highly accurate, reproducible results in ERG experiments quickly and with minimal training beyond introduction to electrophysiology.