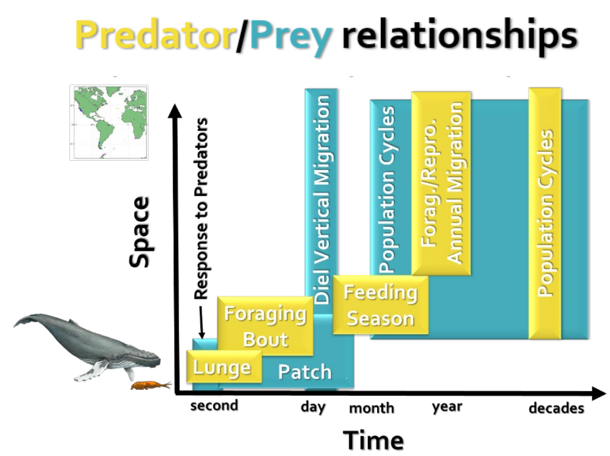
Research statement

Evolution and mechanics of filter feeding in marine megafauna

The questions that drive my research involve the mechanics, physiological adaptations and environmental conditions that determine how top predators find and catch food. Particularly I examine how the interactions between predators and prey affect and are affected by local ecology across a range of spatial and temporal scales. Animals operate in the short term on the information available to them (e.g., Cade et al. 2021, *Animal Behaviour,* Hein et al. 2020, *Current Biology,* Cade et al.2020, *PNAS)*[1], but conservation, management and ecological questions are typically interested in population scales and large-scale ecosystem impacts. **My work bridges these gaps, examining how animal-scale behaviors are affected by mesoscale processes, and vice versa.**

At a fundamental level, the heterogenous distribution of resources in the environment drives the ecology and evolution of every living thing, from plants to people. Many behaviors, including migration, hibernation and diel patterns of behavior, can be attributed to the needs of organisms to thrive despite temporal or spatial variability in resources. My research focuses on how variability in patchily distributed resources at spatial and temporal scales that range from microscopic to ocean basins drives the behaviors and physical adaptations of organisms, **specifically as it relates to predator-prey interactions, foraging efficiency and prey selection** (Cade et al. 2022, *Frontiers in Marine Science,* Cade et al. 2021, *Functional Ecology,* Goldbogen, Cade et al. 2019, *Science)*.

The majority of my work has focused on filter-feeding marine megafauna, which includes elasmobranchs like whale sharks (Cade et al. 2020, *JEB)*, manta rays (Levenson et al., in prep) and basking sharks (Chapple, Cade et al., 2024, Cade et al., in prep), as well as the baleen whales that have been my primary focal system. These animals have outsized influences on their environment and are extreme examples of how animals are driven to exploit patchily distributed resources. Trained as a mathematician as an undergraduate, I switched careers after 6 years of teaching math to become a biologist because I am fascinated by the fundamental behaviors that determine how ecosystems function and how life diminishes or thrives. As complex systems, predator-prey interactions in heterogenous environments represent a grand challenge for evolutionary biologists and ecologists that requires **the integration of mathematical models, theoretical principles, and empirical data**. Most work in this area has been limited to lab studies and may not reflect the full breadth and complexity of natural systems, particularly with respect to the wide range of temporal and spatial scales over which predator-prey interactions take place. My research program to date has directly addressed this knowledge gap in a natural pelagic system that exhibits extreme predator-prey size ratios and important temporal features that range from individual feeding events and escape reactions that take place in an instant, to evolutionary arms races across deep time. This integrated approach is broadly applicable to many biological systems and can serves as a template for the development of new theoretical approaches and technologies that bridge lab and field research and have implications for the evolution of organisms and their survival in an anthropogenic era characterized by rapid change and environmental degradation.



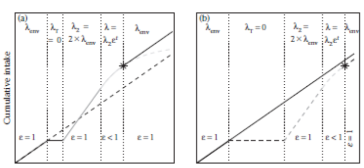
Baleen whales and their prey interact at spatial and temporal scales that range from seconds to decades and cm to hemispheres

[1] All citations listed in full in C.V.

Historically, the realm of comprehensive ecological theories and principles has largely been terrestrial due to the accessibility of this environment in comparison to the vast ocean expanses that are inhospitable to direct observation. Recent technological innovations, however, have allowed organisms and ecological relationships in the open ocean to be studied in new and exciting ways. While vessel-attached active acoustic systems allow the study of the distribution of planktonic and fisheries resources, bio-logging technology utilizing animal-attached data-loggers allow predator behavior to be studied *in situ*. Together, these processes allow examination of predator-prey systems at a variety of spatial and temporal scales. As such, my research **has both developed and taken advantage of these new technologies** (Cade et al. 2021, *Animal Biotelemetry,* Cade et al. 2018, *JEB,* Cade et al. 2014, *Limnology & Oceanography)* to study fundamental questions regarding the exploitation of patchy resource and the evolution of predator and prey behavior in a system that has previously been difficult to observe.

The primary tools of my field research are accelerometer-based bio-logging tags to study predators, fisheries acoustics techniques to study prey, and remote sensing techniques to study the environmental drivers of resource distribution. One of my strengths as a researcher is a broad quantitative training that has allowed me to develop fluency at an instructional level for a wide range of technical approaches. Members of my research lab benefit from my ability to adapt and develop new technologies, and my students benefit from my familiarity with a broad range of approaches. My work developing and disseminating tools for converting raw bio-logging data into metrics of animal orientation, motion and position (Cade et al, 2021, Animal Biotelemetry and associated virtual workshop) **was a large part of why I was honored with an Early Career Award by the International Bio-logging Society for "continually pushing the field by developing new bio-logging technologies and computational workflows that have changed the way we study predator/prey dynamics in the open ocean."**

Tagging a blue whale in Monterey Bay (NMFS permit #20430, Cade et al. 2016, *Current Bio*)



Modeling socially enhanced foraging strategies (Cade et al. 2021, *Animal Behaviour*)

Filming the escape response of anchovies to a looming stimulus (Cade et al. 2020, *PNAS*)

Although I have active ocean-based research projects in Monterey Bay and around the world, including the Antarctic, my research into predator-prey dynamics **and my use of bio-loggers is well suited to the terrestrial environment near the Owens Valley and the White Mountains surrounding Deep Springs College.** The bio-logging techniques I have pioneered are particularly well-suited to studying the movement, energetics, and spatial use of terrestrial predator populations, including raptors, canids and felines, especially as they relate to potential human conflicts, including with ranchers. The research program I would envision as a professor at Deep Springs would involve a combination of continuing some of my marine work during release semesters, but also developing both ecological programs related to the fauna of the white mountains, and applied programs related to the ranching program at Deep Springs. For instance, equipping livestock with remote transmitting accelerometers can signal to students when animals are in distress and in need of attention. Generally, my research program is driven by my passion to understand the world, to contribute to society, and to fill in gaps in our knowledge base. As a faculty member at Deep Springs, I hope to inspire students (and be inspired by students) in a mutual quest to construct a scientific approach to solving the (many and pressing) problems of today's world. I believe a scientific approach to problem solving can serve as a foundation to a lifetime of exploration and learning.