Flows around some soft corals

Laura Miller

In this presentation, I will discuss the construction and results of numerical simulations quantifying flows around several species of soft corals. In the first project, the flows near the tentacles of xeniid soft corals are quantified for the first time. Their active pulsations are thought to enhance their symbionts' photosynthetic rates by up to an order of magnitude. These polyps are approximately 1 cm in diameter and pulse at frequencies between approximately 0.5 and 1 Hz. As a result, the frequency-based Reynolds number calculated using the tentacle length and pulse frequency is on the order of 10 and rapidly decays as with distance from the polyp. This introduces the question of how these corals minimize the reversibility of the flow and bring in new volumes of fluid during each pulse. We estimate the Péclet number of the bulk flow generated by the coral as being on the order of 100–1000 whereas the flow between the bristles of the tentacles is on the order of 10. This illustrates the importance of advective transport in removing oxygen waste. In the second project, the flows through the elaborate branching structures of gorgonian colonies are considered. As water moves through the elaborate branches, it is slowed, and recirculation zones can form downstream of the colony. At the smaller scale, individual polyps that emerge from the branches expand their tentacles, further slowing the flow. At the smallest scale, the tentacles are covered in tiny pinnules where exchange occurs. We quantified the gap to diameter ratios for various gorgonians at the scale of the branches, the polyp tentacles and the pinnules. We then used computational fluid dynamics to determine the flow patterns at all three levels of branching. We quantified the leakiness between the branches, tentacles and pinnules over the biologically relevant range of Reynolds numbers and gap-to-diameter ratios, and found that the branches and tentacles can act as either leaky rakes or solid plates depending upon these dimensionless parameters. The pinnules, in contrast, mostly impede the flow. Using an agent-based modeling framework, we quantified plankton capture as a function of the gap-to diameter ratio of the branches and the Reynolds number. We found that the capture rate depends critically on both morphology and Reynolds number.