The use of spatially explicit coupled models of circulation, ecosystems and individuals to study marine ecological problems: the marriage of physics and biology

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Marine fish populations, often the object of intense commercial harvests by humans, comprise some of the largest (in number) vertebrate populations in the world. Large year-to-year fluctuations in abundance are usually driven by recruitment or the interannual variations in the spawning success and survival of the newly born fishes The sea in which the fish live is a dynamic and complex domain.

To this end, we have studied the physical and biological causes of recruitment variability in walleye pollock in the western Gulf of Alaska for almost two decades. During the course of this work, a set of coupled biophysical models has been developed to help us understand the causes of recruitment variation. Three coupled models come into play. A three dimensional, primitive equation model of the hydrodynamics and circulation of the study region [1] provides the spatial framework needed to address the problem; an individual-based model of the early life stages of pollock [3,5] describes the biology of the target organism; and a lower trophic level ecosystem model of nutrient dynamics, phytoplankton and zooplankton abundance provides a spatially and temporally dynamic prey source for young pollock (as variations in food are thought to be important to recruitment variability).

In this talk, we briefly describe the models, their development and some general issues with model development and model coupling [2] in the context of providing a tool with which to address the different relevant spatial and temporal scales in the marine ecosystem. We then present (1) specific examples of the use of model output visualization methods such as three-dimensional virtual reality

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and (2) model experiments. One example, a factorial model experiment [4] was designed to examine possible factors that may have contributed to the evolution of the spatial location and timing of pollock spawning in the Gulf of Alaska. We discuss the role that the prey model has played in increasing our understanding of the recruitment process. In conclusion, we evaluate the role of this set of coupled models in our studies of the recruitment process, and how they may be further developed (such as two-way IBM-prey model coupling, more complicated behaviors based on past history, and more emphasis on sources of mortality, especially in the juvenile stage) based on what we have learned.

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