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Abstract

Environmental change resulting from natural or anthropogenic forcing can have profound impacts on the structure and function of marine and coastal ecosystems. Yet, determining environmental processes governing population dynamics of marine and anadromous fish species remains an elusive problem that has practical management implications. In this thesis, I use a cross-system comparative approach to examine environmental forcing pathways linking climatic and ocean processes to dynamics of Pacific salmon (*Oncorhynchus* spp.) populations in the Northeast Pacific Ocean. I begin by assessing the evidence for population-level responses to inter-annual changes in two meso-scale ocean processes, phytoplankton dynamics and ocean currents, which represent critical links within two alternative sets of environmental forcing pathways. In the first set of pathways, vertical ocean transport and subsequent phytoplankton dynamics are hypothesized to mediate the effects of climate variability on higher-trophic-level species, whereas in the second set of pathways, climate effects are hypothesized to be mediated by horizontal ocean transport and subsequent advection of plankton into coastal areas. I show that both phytoplankton dynamics and ocean current patterns are strongly associated with changes in salmon productivity, indicating that both sets of hypothesized pathways may drive salmon dynamics. However, the magnitude and direction of the effects were conditional on the latitude of juvenile salmon ocean entry, suggesting that the relative importance of different environmental pathways may be region dependent. Next, I use a novel quantitative method, probabilistic networks, to examine the joint effect and relative strength of 17 potential environmental pathways linking large-scale climate processes to Pacific salmon dynamics. I show that multiple environmental pathways can simultaneously impact salmon population dynamics, including multiple pathways originating from the same climatic process. Finally, I use a policy perspective to examine how challenges arising from a highly migratory life history can impede efforts to integrate Pacific salmon into ecosystem-based management policies. My findings indicate that ecosystem-based management policies should explicitly account for mismatches in the scale at which ecosystem services are provided by highly migratory species and the scale at which human activities and natural processes impact those services to achieve more effective integration. Collectively, my thesis demonstrates that climatic and ocean processes can impact higher-trophic-level species via multiple simultaneously operating environmental pathways and accounting for spatial heterogeneity in the relative importance of these pathways may be critical to developing effective management strategies that are robust to future environmental change.

Keywords: population dynamics; Pacific salmon; environmental change; spatial non-stationarity; ecosystem-based management; productivity