Insights for stock assessment and empirical prerecruit indices from an environmentally forced individual-based model of early life history stages for west coast rockfishes

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Recruitment variability to populations of winter-spawning rockfish derives primarily from highly variable survival through the larval stage, presumably as a consequence of environmental and ecological conditions affecting early life history stages. Existing studies relate recruitment success to mean environmental conditions over (biologically) arbitrarily defined periods spanning one or more months, yet environmental processes thought to be critical to productivity (hence larval survival) vary substantially at shorter time scales, and spawning does not occur with uniform intensity over protracted periods. We have developed and continue to extend a modeling framework in which individual-based models for larval and juvenile rockfish are used to integrate the effects of wind-forced cross-shelf circulation and production in a coastal upwelling system on growth, transport, and survival. Predictions of recruitment success are obtained by integrating the joint probability of: 1) survival conditional on birth date; and 2) entering the plankton on a given date, where the latter is based on the distribution of spawning over time. Comparison to recruitment indices taken from stock assessments indicates that the model performs best for spawning seasons matching those reported in the literature. In contrast, recruitment indices based on fixed-time surveys (e.g. oceanographic surveys, diver surveys, and seabird diets) are best predicted for (hypothetical) spawning seasons consistently centered in March, regardless of species, which suggests that, for some rockfish species, such indices are a biased measure of reproductive success.

A habitat-specific approach for incorporating environmental variation into stock forecasting models

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Habitat conditions for pelagic species are known to vary widely in time and place, creating challenges for accurately predicting the productivity of fishery stocks. We discuss a conceptual approach incorporating habitat transitions to improve the forecasting power of fishery stocks using environmental predictors. We tested this conceptual approach in Puget Sound Chinook salmon populations. On one hand, empirical estimation of population size and productivity is relatively simple compared to marine fish stocks due to the anadromous and semelparous life history of salmon, yet these same characteristics often result in large fluctuations in abundance, and low predictive power for standard stock forecasting approaches that assume static juvenile mortality across years. We conceptualized the Chinook salmon life cycle into four habitat-specific life stages (freshwater, tidal delta, bay, and ocean), and developed environmental predictors that coincided with the periods of residency in these habitats. The best predictors of recruitment in two populations included a combination of freshwater and marine predictors and an estimate of egg production. Our models explained 75–95% of the variation in return rate, had very high forecasting precision, and outperformed model forecasts that assumed natural mortality of each age class was fixed among cohorts. Our results suggest that an environmental-based forecasting approach that utilizes the concept of life stage specific variation tied to habitats offers a way to surmount the challenge of incorporating highly variable natural juvenile mortality in some pelagic stocks.

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