Performance of alternative assessment methods for Pacific Cod (*Gadus macrocephalus*) in British Columbia: a difficult-to-age species with highly uncertain productivity

Robyn E. Forrest

Abstract:
International best practice for ecosystem-based fishery management recommends using a tiered approach to determine the most appropriate assessment method and harvest control rule for a species, based on whether it is data-rich, data-moderate or data-poor. As Canada seeks to implement a tiered approach for providing catch advice for Pacific groundfishes, a major question is how to assess stocks without reliable age-composition data. Age-composition data inform estimates of important parameters defining growth, productivity and selectivity, and therefore influence estimates of fishery reference points as well as stock status. Delay-difference models represent an alternative to explicit age-structured models, subject to certain assumptions about growth, mortality and selectivity. Violation of these assumptions can lead to biased assessment results that impact achievement of fishery objectives. We use closed-loop simulation to test the performance of the delay-difference model, compared with an explicitly age-structured model, for a volatile, difficult-to-age species, Pacific Cod (*Gadus macrocephalus*), in northern British Columbia. We test performance of six alternative harvest control rules against a set of fishery objectives, under alternative configurations of natural mortality (constant or density-dependent) and selectivity (knife-edged or logistic). We explore mechanisms for differences in performance, particularly the propagation of assessment errors and the contribution of age-composition data. We show that even when assessment results are biased, some harvest control rules can still produce desirable management outcomes. The magnitude of trade-offs between conservation and economic objectives was, however, large in some cases, underlining the importance of measuring performance in terms of management outcomes rather than uncertainty *per se*.

Contact Author: Robyn Forrest. Fisheries and Oceans Canada, Pacific Biological Station, 3190 Hammond Bay Road, Nanaimo, BC, V9T 6N7, Canada. Robyn.Forrest@dfo-mpo.gc.ca.

Keywords: Fishery reference points, harvest control rule, closed-loop simulation, *Gadus macrocephalus*, density-dependent mortality, delay-difference model