Title

Authors

Affiliations

Abstract:

**Introduction**

* Stock assessments
  + History of stock assessments – why we do them, and typical reference points (Smith 1988; Restrepo 1999)
  + Recent metrics / reference points
    - Number of age / size classes (Berkeley et al. 2004)
    - Density ratio (Babcock and MacCall 2011)
      * Advantage over depletion-based stock reduction analysis (which requires strong catch history data) (Dick and MacCall 2011)
* Marine fish species age distribution
  + Effect of fishing
    - truncation of age structure, decreased biomass, reduced population size (Beverton and Holt 1957; Hsieh et al. 2010)
    - reduces spatial heterogeneity 🡪 reduces resilience and increases fluctuation amplitude in transient dynamics (Hsieh et al. 2010)
    - we assume effects of fishing are reversible, but this may not be true to the extent we believe it to be (Jennings 2000)
* Marine protected areas / marine reserves
  + Definition of MPA( areas designated for special protection to enhance the management of marine resources) vs. marine reserve (zones within an MPA where removal or disturbance of resources is prohibited, sometimes called “closed” or “no-take” areas) (National Research Council 2001)
  + Gradient of MPAs (lightly, strongly, fully protected) (Lubchenco and Grorud-Colvert 2015)
  + History of MPAs internationally and in USA (National Research Council 2001; Lubchenco and Grorud-Colvert 2015)
* Effects of marine reserves
  + Tension between short-term losses and long-term benefits of reserves (Brown et al. 2015)
  + Ecological effects within / outside reserves (Lubchenco et al. 2003)
  + Effect on density, biomass, organism size, and diversity (Halpern 2003; Lester et al. 2009)
  + Effects may depend on fish commercial value / bycatch (Claudet et al. 2010)
  + Can help mitigate / promote adaptations to climate change (Roberts et al. 2017)
* Other effects of marine reserve implementation
  + Transient dynamics
    - History / development (Hastings 2004)
    - Importance of M and k values for describing transient dynamics and other key findings for west coast rockfish species (Kaplan et al. in review; White et al. 2013)
  + Importance of variability about population trajectory
  + Stochastic models (instead of deterministic) can help account for process and observation error (White et al. 2011)
* Designation of marine reserves off coast of Oregon
  + Goals of marine reserves
  + Upcoming assessment in 2023
* Description of study species
  + Black rockfish economic importance (Love et al. 2002; NOAA Fisheries West Coast Region 2018)
  + Slow population dynamics (black rockfish) (Bobko and Berkeley 2004)
  + Cabezon (Hannah et al. 2009)
  + Lingcod (Hamel et al. 2009)
  + Copper rockfish (Lea 2001; Cope et al. 2013)
  + Compare life history characteristics, should lead to different timescales for transient dynamics (Kaplan et al. in review)
* Overview of methods
  + Reconstruction of base model, based off of (Babcock and MacCall 2011)
  + Minor modifications: update life history characteristics with most recent stock assessments
  + Recruitment independent of spawning stock biomass (stochastic model)
  + Variability around population trajectory
  + Adapt population dynamics to take transient dynamic trends into account (Kaplan et al. in review; White et al. 2013)
  + Exploration of effect of range of density ratios (as opposed to point estimate)
* Hypotheses
  + Species with lower mortality rates and higher growth rates will show shorter transient timescales
  + More accurate population dynamics = better informed adaptive management given updated model compared to original base model
  + Better adaptive fisheries management should result in higher biomass, individual size of organisms, density, and species richness (White et al. 2010)
    - link back to ODFW marine reserve program goals

**Methods**

* Reconstruction of base model
  + Breakdown of sub-models into various functions
  + For more detailed equations and parameters, see Appendix A.
  + Reconstruction of base model, based off of (Babcock and MacCall 2011)
* Minor modifications: update life history characteristics with most recent stock assessments
* Recruitment independent of spawning stock biomass (stochastic model)
* Variability around population trajectory
* Adapt population dynamics to take transient dynamic trends into account (Kaplan et al. in review; White et al. 2013)
* Exploration of effect of range of density ratios (as opposed to point estimate)

Table 1. Study species parameters

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Species | | **Black Rockfish** | **Cabezon** | **Lingcod** | **Copper Rockfish** |
|  | Source | | (Cope et al. 2016) | (Cope and Key 2009) |  |  |
| Category | Value | Symbol |
| Lifespan | Age at recruitment | arec | 3 |  |  |  |
| Maximum age | amax | 40 |  |  |  |
| Natural mortality | M | 0.17 |  |  |  |
| Female weight at length | Coefficient | af |  |  |  |  |
| Exponent | bf |  |  |  |  |
| Female growth | Age 1 | a1 |  |  |  |  |
| Length at age 1 | L1 |  |  |  |  |
| Age 2 | a2 |  |  |  |  |
| Length at age 2 | L2 |  |  |  |  |
| von Bertalanffy growth parameter | kf |  |  |  |  |
| Male weight at length | Coefficient | am |  |  |  |  |
| Exponent | bm |  |  |  |  |
| Male growth | Age 1 | a1 |  |  |  |  |
| Length at age 1 | L1 |  |  |  |  |
| Age 2 | a2 |  |  |  |  |
| Length at age 2 | L2 |  |  |  |  |
| von Bertalanffy growth parameter | km |  |  |  |  |
| Reproduction | Length at 50% maturity | L50 |  |  |  |  |
|  | Slope of maturity curve | Kmat |  |  |  |  |
|  | Recruitment standard deviation | σR |  |  |  |  |
|  | Recruitment autocorrelation | ρR |  |  |  |  |
|  | Steepness | h |  |  |  |  |
|  | Egg production slope | ME |  |  |  |  |
|  | Egg production intercept | BE |  |  |  |  |
| Movement | Larval drift proportion | DL |  |  |  |  |
|  | Adult movement proportion | DA |  |  |  |  |
| Fishing | Depletion | D |  |  |  |  |
|  | Associated fishing mortality | FD |  |  |  |  |
| Selectivity | Number of fleets |  |  |  |  |  |
|  | Fraction of fishery | CF |  |  |  |  |
|  | Length at first vulnerability | Lv |  |  |  |  |
|  | Slope of upcurve | Mu |  |  |  |  |
|  | Upcurve halfway point | Hu |  |  |  |  |
|  | Switch length | Ls |  |  |  |  |
|  | Length at start of downcurve | Ld |  |  |  |  |
|  | Slope of downcurve | Md |  |  |  |  |
|  | Downcurve halfway point | Hd |  |  |  |  |
|  | Final selectivity | Sf |  |  |  |  |
| Sampling | Proportion of positive transects |  |  |  |  |  |
|  | Mean individuals seen in positive transects |  |  |  |  |  |
|  | Standard deviation of positive transects |  |  |  |  |  |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |

Table 2. Control rules

**Results**

**Discussion**

* Future directions
  + Overall, complex interdependence of reserve size, fishing intensity, and larval dispersal patterns shapes the biological response to reserves over large spatial and temporal scales (White et al. 2011) – inclusion of larval dispersal patterns / better understanding of it
  + Current problems in management (Beddington et al. 2007)
  + Management shouldn’t be restricted to a certain methodology (Degnbol et al. 2006)
    - Reserves work best when partnered with other management techniques (Lubchenco et al. 2003)
* Improving the reserves
  + NEOLI factors (Edgar et al. 2014)

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**Appendix A**

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