Chatham Strait Sablefish

Age-Structured Model Documentation

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**Model Overview**  
The Chatham Strait sablefish model is an age-structured model in which parameters and derived quantities are estimated through maximum likelihood methods. Variances of parameters and derived quantities are available via parametric bootstrap, MCMC, or Delta methods. Model abundance is scaled by Alaska Department of Fish and Game (ADF&G) mark-recapture estimates of abundance as well as catch-per-unit-effort (CPUE) for both the commercial longline fishery and the ADF&G longline survey.

**DATA SOURCES:**

1. Commercial fishery:
   * Total annual catch
   * Age-composition
   * CPUE
   * Recapture data from tagged and released fish
2. ADF&G longline survey survey:
   * Age-composition
   * CPUE
   * Recapture data from tagged and released fish
3. Fish tagged and released in the pot survey for recapture in the survey and fishery

**OBJECTIVE FUNCTION**

1. Likelihoods:
   1. Total annual commercial catch
   2. Mark-recapture estimates of abundance for both fishery and survey
   3. Age composition for fishery and survey
   4. CPUE for fishery and survey
2. Penalties:
   1. Annual recruitment deviations
   2. Year 1 abundance deviations
   3. Mean recruitment
   4. Mean year 1 abundance

**MODEL\_STRUCTURES**

1. **Sex-specific**
   * sex-specific (distinct abundance, mortality, selectivity for each sex)
   * uses NOAA longline survey selectivity inputs, male and female
   * calculates sex-specific fishery longline selectivity  
     (accounts for highgrading, which is illegal in the federal fishery but not in the State fishery)
   * two recapture events for the mark-recapture estimates - fishery and survey  
     These use sex-specific capture rates and selectivities and estimate abundance at the *beginning* of the survey and fishery, respectively
   * Natural mortality *M* is input at 0.1
2. **Single-sex**
   * Single-sex structure; no explicit sex parameters or derived quantities
   * uses AVERAGE NOAA longline survey selectivity input, averaged between male and female
   * calculates a single fishery longline selectivity for both sexes (accounts for highgrading, which is illegal in the federal fishery but not in the State fishery)
   * two recapture events for the mark-recapture estimates - fishery and survey  
     These use general capture rates and selectivities and estimate mean abundance at the *middle* of the survey and fishery, respectively  
     (Note that the survey is so short that the middle and beginning are the same)
   * Natural mortality *M* is input at 0.1

In the equations below, the subscript for sex *s* is present. This applies to the sex-specific model structure. For clarity, equations from the sex-unified model are not presented, and the appropriate unified population structure is assumed.

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| Table 1. Some initial notation | |
| Symbol | Description |
| Index |  |
| y, i | Year |
| a, j | Age |
| s | Sex |
| *µr* | Mean annual recruitment |
| *µy1* | Mean year 1 abundance |
| *σr* | Recruitment standard deviation |
| *σy1* | Year 1 standard deviation |
| *Zy,a,s* | Total mortality by year *y* and age *a* |
|  | Survival until the month of the fishery |
|  | Survival until the month of the survey |
|  | Survival until spawning |
| *Ta,a’* | Aging-error matrix |
|  | Catchability for early ADFG survey (1988 – 1996) CPUE |
|  | Catchability for late ADFG survey (1996 – Present) CPUE |
|  | Catchability for commercial fishery CPUE |
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| Fishing mortality |
| Commercial longline fishery selectivity |
| Annual fishing mortality at age and sex |

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| Abundance |  |  |
| Start Year |  |  |
|  | *a = a*0  *a*0 < ­*a* < *a+* | Number at age of recruitment (2)  Number at ages between recruitment and including first year plus class |
| Subsequent years |  |  |
|  | *a = a*0  *a*0 < ­*a* < *a+*  *a* = *a+* | Number at age of recruitment (2)  Number at ages between recruitment and plus class  Number in plus class (42+) |
| *NOTE: for the sex-specific model, recruitment is simply divided in half under the assumption of equal sex-division at hatching* | | |
| Female spawning biomass    *NOTE: for the sex-specific model, the above uses only the female abundance at age. The sex-unified model uses total abundance divided by 2.* | | |

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| Commercial fishery catch, effective sample size, and standard deviation of normalized residuals | | | | |
| Total annual catch |  | |  | |
| Fishery age composition |  | |  | |
| Effective sample size |  | |  | |
| Standard deviation of normalized residuals | |  | |  |
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| Mark-Recapture abundances | | |
| Commercial longline fishery | | |
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| ADF&G longline survey |  |  |
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| CPUE |
| ADF&G longline survey: 1988 – 1996    ADF&G longline survey: 1996 – present    Commercial longline fishery |

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| Penalties |
| Penalty for year 1 abundance deviations |
| Penalty on recruitment deviations |
| Penalty on average recruitment parameter |
| Penalty on average year 1 abundance parameter |

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| Likelihoods |
| Commercial longline fishery |
| Mark-recapture (fishery) |
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| Mark-recapture (survey) |
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| ADF&G Longline Survey CPUE |
|  |
| Commercial longline fishery CPUE |
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| Fishery age composition (*n* = sample size)    Longline survey age composition (*n* = sample size) |
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