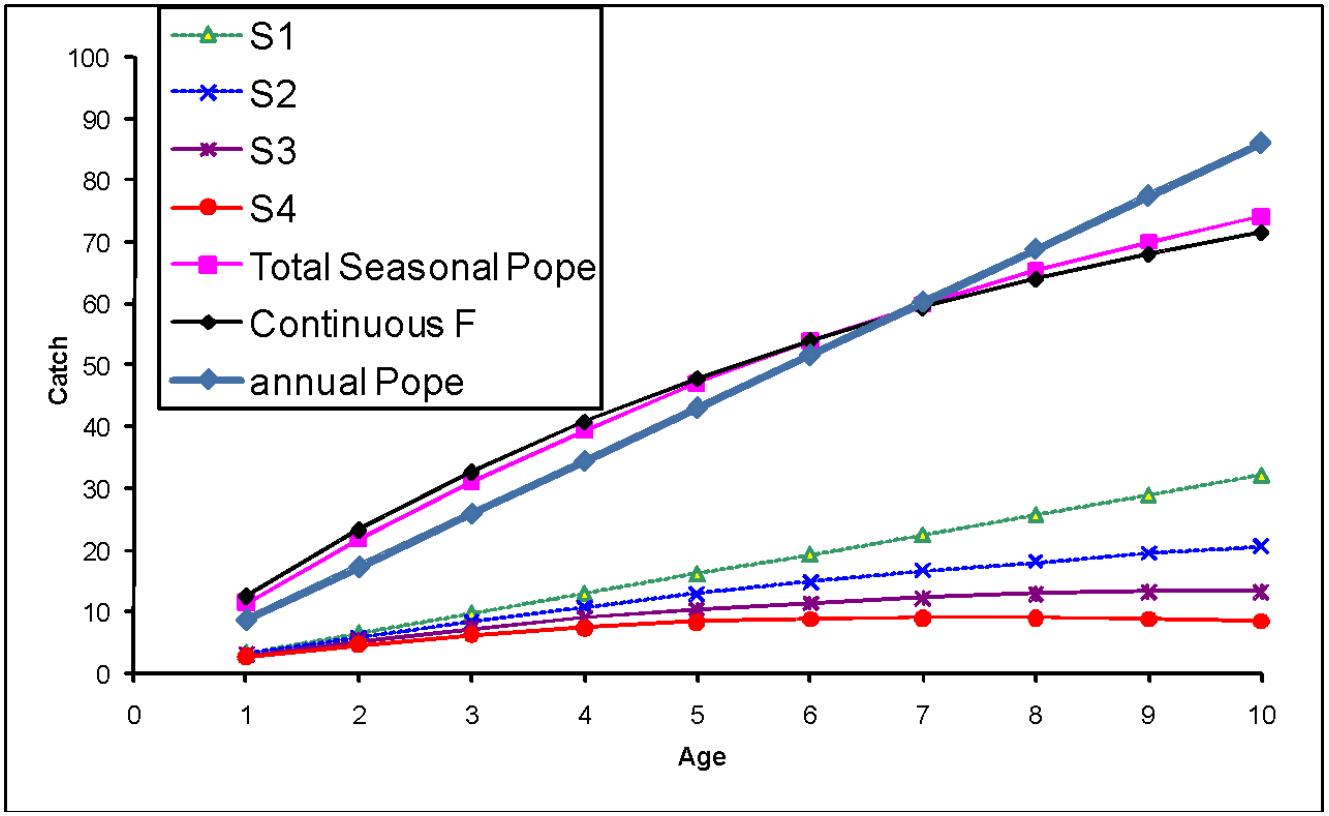
Fishing mortality (F)

Continuous F vs. Pope's Approx.

- **With Pope's**
  - Decays N-at-age to mid-season using M
  - Removes catch instantaneously using Hrate and selectivity, with Hrate calculated to exactly match the observed landed catch
  - Decays fishery survivors to end of season using M
  - Z calculated as $\log(N_{t+1} / N_t)$ and used to interpolate N at age within the season.
- **With continuous F**
  - Uses M1 + M2 + F to calculate Z at age
- **Implications of fishery selectivity differ between the two approaches**

Selectivity & Seasons



With N-at-age constant (100) and linear ramp in selectivity, we need multiple seasons for Pope's to approximate continuous F if F is high (here, 1.8).

Hybrid F

- Start by doing a Pope's calculation of mid-season exploitation rate:
  Hrate = catch_ret_obs(f,t)/vbio
- Then convert to an estimate of equivalent F
  F=-log(1.-Hrate)
- Then tune the F values in a fixed number (3-5) of iterations to approximate the observed catch
- The tuning converges quickly because algorithm anticipates what Z will be after F's are adjusted

F comparison

	Fmethod		
	1	2	3
	Pope's	parameters	hybrid
N_iter:	458	846	469
runtime(sec):	85	130	95
LIKELIHOOD	1327.64	1327.68	1327.68
endspbio	6017.21	5797.93	5798.08
se(endspbio)	1331.46	1293.99	1293.93

F using many parameters vs F using many internally calculated factors has no impact on the variance of derived quantities.

hybrid vs parameter

- Both use the same F calculations
- Hybrid best when F is low
- At high F, hybrid's algorithm to maintain match to catch inhibits movement towards convergence
- Parameter approach can be configured to get starting value for F parameter during early phases using hybrid, then converts to parameter to finish the run
- F method = 4 gives best flexibility because it allows hybrid vs parameter conversion on a fleet-specific basis

F and Discards

- ***F*** creates total catch
- Retention can partition into retained and discarded catch
- Pope's and Hybrid tune using only retained catch
- Tuning to retained catch can result in poor fit to discard data
- ***F*** as parameter tries, by minimizing total –logL, to fit to both retained and discarded catch. This is best approach if the ***se*** of discards is comparable to ***se*** of retained catch

F and Selectivity

- $F_a = F' * s_a$
- If max (s_a) ≠ 1.0, then ***F'*** compensates
- Even if no age has s_a = 1.0, the ***F'*** is still relative to hypothetical age with s_a = 1.0
- The ***F'*** are what SS3 adjusts in hybrid or gets from a parameter
- When SS3 reports the ***F'*** and the s_a, it does not rescale them to show max(s_a) = 1.0 and corresponding counter-adjustment to the ***F'***

Reporting $F_{f,a}$

- ***F_AT_AGE report:39***
  - Area Fleet Sex Morph Yr Seas Era 0 1 2
  - Where each fleet operates in only one area
  - Where “Morph” is all morphs, settlement events, platoons; e.g. looping all the “g” and reporting their sex.
- ***CATCH_AT_AGE report:40***
- ***DISCARD_AT_AGE report:41***

Reporting ***total F_a***

Two sets of tables in the Dynamic_Bzero report:59

Z_AT_AGE_Annual_2 With_fishery

Bio_Pattern Sex Yr 0 1 2 …..

Where Z comes from ln($N_{t=1}$ / N_t) based on begin of year N's summed across all areas and the subdivisions within Bio_Pattern x Sex

Report_Z_by_area_morph_platoon_2 With_fishery

Area Bio_Pattern Sex BirthSeas Settlement Platoon Morph Yr Seas ….. 0 1 2 ……

Where "Morph" is each "g"

Also report same for: _1 No_fishery _for_Z=M

Reporting overall F: F_std

- The complexities of multiple fleets, areas, growth patterns, seasons, dome-selectivity, etc. wreck havoc with calculation of a single annual total “F” statistic
- Initially, SS3 focused on reporting an annual value for equilibrium SPR and the total exploitation rate (catch/summary biomass)
- Sum of the F’ values across fleets is also available, but it is easily misleading in complex setups
- New option gets F_bar based on age-specific total F
- Uses Z-M approach, where:
  - $Z=\ln(N_{t+1,a+1} / N_{t,a})$ on annual not seasonal basis, and
  - $M=\ln(N_{t+1,a+1} / N_{t,a})$ with fishery turned off

Testing Internal Consistency

- Can we set init_F = F_timeseries = F_forecast = F_MSY and get a constant population at B_MSY?
- MSY depends only on steepness, biology, selectivity and scales with R0. Time series of actual F and recdevs do not affect F_MSY.

1. Do run that includes placeholder for init_catch (and init_F), and forecast set to do a few years of constant catch in forecast.
2. Control.ss_new will contain final parameter values; copy control.ss_new to control.ss to contain the converged biology, steepness, selectivity, R0.
3. Get F_MSY and MSY from the output

Testing Internal Consistency

4. Set init_F and starting F = F_MSY

```
4 # F_Method:  1=Pope midseason rate; 2=F as parameter
2.95 # max F (methods 2-4) or harvest fraction (method
# Read list of fleets that do F as parameter; unlisted
# (A) fleet;
# (B) F_starting_value (ignored if start_PH=1 or readi
# (C) start_PH for fleet's Fparms (99 to stay in hybri
# Terminate list with -9999 for fleet (use -9998 to re
# (A) (B) (C)
 1 0.094107 -1 # FISHERY
-9999 1 1 # end of list
#F_detail template: Fleet Yr Seas F_value catch_se pha
3 #_number of loops for hybrid tuning; 4 precise; 3 fa
#
#_initial_F_parms; for each fleet x season that has in
#_for unconstrained init_F, use an arbitrary initial c
#_ LO HI INIT PRIOR PR_SD  PR_type  PHASE
 0 1 0.094107 10.3 10 0 1 # InitF_seas_1_flt_1FISHERY
```

Testing Internal Consistency

5. Set spawner-recruitment for constancy

```
3 #_Spawner-Recruitment; Options: 1=NA; 2=Ricker; 3=std_B-H; 4=SCA
1  # 0/1 to use steepness in initial equ recruitment calculation
```

```
-3 #_max_bias_adj_in_MPD (typical ~0.8; -3 sets all years to 0.0;
```

With these settings, R in the initial equilibrium will behave like R in the equilibrium MSY calculations.
Then during the time series the constant recruitments will stay at the R0 level and not be bias-adjusted down in anticipation of being estimated to a lognormal pdf.

Testing Internal Consistency

6. Forecast settings

```
1 # Control rule method (0: none; 1: ramp does catch=f(SSB), buffer on F;
# values for top, bottom and buffer exist, but not used when Policy=0
0.3 # Control rule inflection for constant F (as frac of Bzero, e.g. 0.40)
0.1 # Control rule cutoff for no F (as frac of Bzero, e.g. 0.10)
1 # Buffer:  enter Control rule target as fraction of Flimit (e.g. 0.75),
```

```
2 # basis for input Fcast catch: -1=read basis with each obs; 2=dead catch;
#enter list of Fcast catches or Fa; terminate with line having year=-9999
#_Yr Seas Fleet Catch(or_F)
 2002 1 1 3031.83
 2003 1 1 3031.83
 2004 1 1 3031.83
 2005 1 1 3031.83
 2006 1 1 3031.83
-9999 1 1 0
```

With these settings:
Control rule will not reduce F_ABC below F_MSY
First 5 years of 10 year projection will find F to match catch set to MSY
Next 5 years will get forecast catch from F_MSY.

Testing Internal Consistency

- Run:
  - reading from control file, not ss3.par
  - And with –stopph 0, so no parameter estimation
- Result:
  - Biomass, recruitment, F and catch are the same for every year from initial equilibrium through the last year of the forecast.