Appendix 1. Redfish age-structured model

Part A. AD model builder code for the baseline redfish model

```
  //REDFISH AGE-STRUCTURED MODEL
  //JON BRODZIAK NEFSC APRIL 2001
  //MODIFIED TO INCORPORATE NDWG COMMENTS MAY 2001
  //COMMENT LINES BEGIN WITH "//"
DATA_SECTION
  //READ DATA FROM INPUT FILE "RED.DAT"
  init_int styr
  init_int endyr
  init_int nages
  init_int nselages_fish
  init_vector catch_bio(styr,endyr)
  init_int nobs_cpue
  init_ivector yrs_cpue(1,nobs_cpue)
  init_number zfrac_cpue
  init_vector obs_cpue(1,nobs_cpue)
  init_int nobs_fish
  init_ivector yrs_fish(1,nobs_fish)
  init_int nsamples_fish
  init_matrix obs_p_fish(1,nobs_fish,1,nages)
  init_int nobs_srv1
  init_ivector yrs_srv1(1,nobs_srv1)
  init_number zfrac_srv1
  init_vector obs_srv1(1,nobs_srv1)
  init_int nsamples_srv1
  init_matrix obs_p_srv1(1,nobs_srv1,1,nages)
  init_int nobs_srv2
  init_ivector yrs_srv2(1,nobs_srv2)
  init_number zfrac_srv2
  init_vector obs_srv2(1,nobs_srv2)
  init_int nsamples_srv2
  init_matrix obs_p_srv2(1,nobs_srv2,1,nages)
  init_vector wt(1,nages)
  init_number zfrac_spawn
  init_vector maturity(1,nages)
  init_number lambda_recruitment
  init_number lambda_fishery_cpue
  init_number lambda_fishery_age
  init_number lambda_srv1_age
  init_number lambda_biomass_index_srv1
  init_number lambda_srv2_age
  init_number lambda_biomass_index_srv2
  init_number lambda_catch_biomass
  init_number lambda_fishery_sel
  init_number lambda_f_penalty

  int styr_rec

 LOCAL_CALCS
 //COMPUTE YEAR OF FIRST RECRUITMENT DEVIATION TO BE ESTIMATED
  styr_rec=styr-nages+2;
 END_CALCS


INITIALIZATION_SECTION
  //PROVIDE INITIAL PARAMETER VALUES
  //NATURAL MORTALITY (NOT ESTIMATED)
```

```
  M 0.05

  //LOG(MEAN RECRUITMENT) IN THOUSANDS OF FISH
  mean_log_rec 11.5

  //LOG(MEAN ANNUAL FISHING MORTALITY)
  log_avg_fmort -2.5

  //CPUE INDEX PARAMETERS
  q_cpue 1.
  exp_cpue 0.8

  //AUTUMN SURVEY INDEX PARAMETERS
  q1 1.
  log_gamma_srv1 -2.
  log_beta_srv1 0.
  log_a50_srv1 1.5

  //SPRING SURVEY INDEX PARAMETERS
  q2 1.
  exp_srv2 1.
  log_gamma_srv2 -2.
  log_beta_srv2 0.
  log_a50_srv2 1.5

PARAMETER_SECTION
  //DECLARE MODEL PARAMETERS AND VARIABLES
  init_bounded_number M(.02,.25,-1)
  init_number mean_log_rec(1)
  init_bounded_dev_vector rec_dev(styr_rec,endyr,-15,15,3)

  init_bounded_number q_cpue(.01,100.,7)
  init_bounded_number exp_cpue(.25,4.,7)

  init_bounded_number q1(.02,50.,8)
  init_bounded_number log_gamma_srv1(-50.,0.999,4)
  init_bounded_number log_beta_srv1(-50.,10.,4)
  init_bounded_number log_a50_srv1(0.,3.,4)

  init_bounded_number q2(.02,50.,8)
  init_bounded_number exp_srv2(.25,4.,8)
  init_bounded_number log_gamma_srv2(-50.,0.999,4)
  init_bounded_number log_beta_srv2(-50.,10.,4)
  init_bounded_number log_a50_srv2(0.,3.,4)

  init_number log_avg_fmort(2)
  init_bounded_dev_vector fmort_dev(styr,endyr,-15,15,2)

  init_vector log_selcoffs_fish(1,nselages_fish,4)

  vector log_sel_fish(1,nages)
  vector sel(1,nages)
  vector sel_srv1(1,nages)
  vector sel_srv2(1,nages)
  number avgsel_fish

  vector rec_years(styr_rec,endyr)
  vector years(styr,endyr)
```

```
  vector ages(1,nages)

  vector totn_srv1(styr,endyr)
  vector totn_srv2(styr,endyr)
  vector popnbiom(styr,endyr)
  sdreport_vector spawnbiom(styr,endyr)
  sdreport_vector recruitment(styr,endyr)
  vector explbiom(styr,endyr)
  vector surplus_production(styr,endyr-1)
  vector pred_cpue(styr,endyr)
  vector pred_srv1(styr,endyr)
  vector pred_srv2(styr,endyr)
  matrix pred_p_fish(styr,endyr,1,nages)
  matrix pred_p_srv1(styr,endyr,1,nages)
  matrix pred_p_srv2(styr,endyr,1,nages)
  vector pred_catch(styr,endyr)

  vector natage_cpue(1,nages)
  vector natage_srv1(1,nages)
  vector natage_srv2(1,nages)
  vector natage_spawn(1,nages)
  matrix natage(styr,endyr,1,nages)
  matrix catage(styr,endyr,1,nages)
  matrix Z(styr,endyr,1,nages)
  matrix F(styr,endyr,1,nages)
  matrix S(styr,endyr,1,nages)
  number beta_srv1
  number gamma_srv1
  number a50_srv1
  number beta_srv2
  number gamma_srv2
  number a50_srv2
  number survival

  vector offset(1,3)
  number rec_like
  number catch_like
  vector age_like(1,3)
  vector sel_like(1,3)
  number fpen
  number cpue_like
  number srv1_like
  number srv2_like

  objective_function_value f

  sdreport_number endbiom
  sdreport_number depletion_popnbiom
  sdreport_number endspawn
  sdreport_number depspawn
  sdreport_number deppopnbiom63
  sdreport_number depspawn63
  sdreport_vector endN(1,nages)
  likeprof_number endF


RUNTIME_SECTION
  convergence_criteria 1e-6;
```

```
PRELIMINARY_CALCS_SECTION

  //SET TIME HORIZON:years
  for (int i=styr; i<=endyr; i++)
    {
    years(i)=i;
    }

  //SET RECRUITMENT TIME HORIZON:rec_years
  for (i=styr_rec; i<=endyr; i++)
    {
    rec_years(i)=i;
    }

  //SET AGE CLASSES:ages
  for (i=1; i<=nages; i++)
    {
    ages(i)=i;
    }

  //RESCALE FISHERY CPUE INDEX
  obs_cpue*=10000;

  //RESCALE SURVEY1 INDEX
  obs_srv1*=100;

  //RESCALE SURVEY2 INDEX
  obs_srv2*=100;

  //CHECK INPUT DATA
  cout << "START YEAR: "<<styr<< endl;
  cout << "END YEAR: "<<endyr<< endl;
  cout << "AGE CLASSES: "<<nages<<endl;
  cout << "FISHERY SELECTED AGES: "<<nselages_fish<<endl;
  cout << "CATCH BIOMASS" << endl;
  cout << catch_bio << endl;
  cout << "FISHERY YEARS"<<endl;
  cout << yrs_fish<< endl;
  cout << "FISHERY CPUE YEARS"<<endl;
  cout << yrs_cpue<< endl;
  cout << "FRACTION OF Z BEFORE CPUE"<<endl;
  cout << zfrac_cpue<< endl;
  cout << "FISHERY CPUE INDEX"<<endl;
  cout << obs_cpue<< endl;
  cout << "SURVEY1 YEARS"<<endl;
  cout << yrs_srv1<< endl;
  cout << "FRACTION OF Z BEFORE SURVEY1"<<endl;
  cout << zfrac_srv1<< endl;
  cout << "SURVEY1 INDEX"<<endl;
  cout << obs_srv1<< endl;
  cout << "SURVEY2 YEARS"<<endl;
  cout << yrs_srv2<< endl;
  cout << "FRACTION OF Z BEFORE SURVEY2"<<endl;
  cout << zfrac_srv2<< endl;
  cout << "SURVEY2 INDEX"<<endl;
  cout << obs_srv2<< endl;
  cout << "FISHERY AGE COMPOSITION"<<endl;
```

```
cout << obs_p_fish<< endl;
cout << "SURVEY1 AGE COMPOSITION"<<endl;
cout << obs_p_srv1<< endl;
cout << "SURVEY2 AGE COMPOSITION"<<endl;
cout << obs_p_srv2<< endl;
cout << "WEIGHT AT AGE"<<endl;
cout << wt<< endl;
cout << "FRACTION OF Z BEFORE SPAWNING"<<endl;
cout << zfrac_spawn<< endl;
cout << "MATURITY AT AGE"<<endl;
cout << maturity<< endl;
cout << "LAMBDA RECRUITMENT: " << lambda_recruitment <<endl;
cout << "LAMBDA FISHERY CPUE: " <<lambda_fishery_cpue <<endl;
cout << "LAMBDA FISHERY AGE: " <<lambda_fishery_age <<endl;
cout << "LAMBDA SURVEY1 AGE: " <<lambda_srv1_age <<endl;
cout << "LAMBDA SURVEY1 INDEX: " <<lambda_biomass_index_srv1 <<endl;
cout << "LAMBDA SURVEY2 AGE: " <<lambda_srv2_age <<endl;
cout << "LAMBDA SURVEY2 INDEX: " <<lambda_biomass_index_srv2 <<endl;
cout << "LAMBDA CATCH BIOMASS: " <<lambda_catch_biomass <<endl;
cout << "LAMBDA FISHERY SELECTIVITY: " <<lambda_fishery_sel <<endl;
cout << "LAMBDA F PENALTY: " <<lambda_f_penalty <<endl;

//COMPUTE OFFSET FOR FISHERY AGE MULTINOMIAL
    for (i=1; i <= nobs_fish; i++)
      {
      //CHECK FOR FISHERY AGE DATA IN YEAR i, -99 = MISSING DATA
      if (obs_p_fish(i,1) >= 0.0)
        obs_p_fish(i)=obs_p_fish(i)/sum(obs_p_fish(i));
      for (int j=1; j<=nages; j++)
        {
          if (obs_p_fish(i,j)>0.0)
            {
            offset(1)-=nsamples_srv1*obs_p_fish(i,j)*log(obs_p_fish(i,j));
            }
        }
      }
cout << "FISHERY PROPORTION AT AGE DATA" << endl;
cout << obs_p_fish << endl;

//COMPUTE OFFSET FOR AUTUMN SURVEY AGE MULTINOMIAL
    for (i=1; i <= nobs_srv1; i++)
      {
      //CHECK FOR SURVEY1 AGE DATA IN YEAR i, -99 = MISSING DATA
      if (obs_p_srv1(i,1) >= 0.0)
        obs_p_srv1(i)=obs_p_srv1(i)/sum(obs_p_srv1(i));
      for (int j=1; j<=nages; j++)
        {
          if (obs_p_srv1(i,j)>0.0)
            {
            offset(2)-=nsamples_srv1*obs_p_srv1(i,j)*log(obs_p_srv1(i,j));
            }
        }
      }
cout << "SURVEY1 PROPORTION AT AGE DATA" << endl;
cout << obs_p_srv1 << endl;

//COMPUTE OFFSET FOR SPRING SURVEY AGE MULTINOMIAL
    for (i=1; i <= nobs_srv2; i++)
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```
        {
        //CHECK FOR SURVEY2 AGE DATA IN YEAR i, -99 = MISSING DATA
        if (obs_p_srv2(i,1) >= 0.0)
          obs_p_srv2(i)=obs_p_srv2(i)/sum(obs_p_srv2(i));
        for (int j=1; j<=nages; j++)
          {
            if (obs_p_srv2(i,j)>0.0)
              {
              offset(3)-=nsamples_srv2*obs_p_srv2(i,j)*log(obs_p_srv2(i,j));
              }
          }
        }
  cout << "SURVEY2 PROPORTION AT AGE DATA" << endl;
  cout << obs_p_srv2 << endl;

TOP_OF_MAIN_SECTION
  //ALLOCATE SPACE IN READ-WRITE MEMORY
  arrmblsize=2000000;
  gradient_structure::set_GRADSTACK_BUFFER_SIZE(2000000);
  gradient_structure::set_CMPDIF_BUFFER_SIZE(60000000);

PROCEDURE_SECTION
  //DO THE FUNCTION CALLS IN SEQUENCE
  get_selectivity();
  get_mortality();
  survival=mfexp(-1.0* M);
  get_numbers_at_age();
  get_catch_at_age();
  evaluate_the_objective_function();

FUNCTION get_selectivity
  //FISHERY SELECTIVITY ESTIMATION FOR AGES 1 TO NSELAGES_FISH
  //SET AVERAGE TO 1 AND THEN RESCALE SO MAX VALUE=1
  for (int j=1;j<=nselages_fish;j++)
    {
    log_sel_fish(j)=log_selcoffs_fish(j);
    }
  for (j=nselages_fish+1;j<=nages;j++)
    {
    log_sel_fish(j)=log_sel_fish(j-1);
    }
  avgsel_fish=log(mean(mfexp(log_selcoffs_fish)));
  log_sel_fish-=log(mean(exp(log_sel_fish)));
  sel=mfexp(log_sel_fish);
  sel/=max(sel);
  //cout<<"FISHERY SELECTIVITY"<<endl;
  //cout<<sel<<endl;
  //cout<<"MAXIMUM VALUE: "<<max(sel)<<endl;

  //AUTUMN SURVEY1 SELECTIVITY ESTIMATION VIA THOMPSON MODEL
  beta_srv1=mfexp(log_beta_srv1);
  gamma_srv1=mfexp(log_gamma_srv1);
  a50_srv1=mfexp(log_a50_srv1);
  for (j=1; j<=nages; j++)
    {
    sel_srv1(j)=(1./(1.-gamma_srv1))*pow((1.-gamma_srv1)/gamma_srv1,
                gamma_srv1)*(exp(beta_srv1*gamma_srv1*(a50_srv1-
                double(j)))/(1+exp(beta_srv1*(a50_srv1-double(j)))));
```

```
    }
  //sel_srv1/=max(sel_srv1);
  //cout<<"SURVEY1 SELECTIVITY"<<endl;
  //cout<<sel_srv1<<endl;
  //cout<<"MAXIMUM VALUE: "<<max(sel_srv1)<<endl;

  //SPRING SURVEY2 SELECTIVITY ESTIMATION VIA THOMPSON MODEL
  beta_srv2=mfexp(log_beta_srv2);
  gamma_srv2=mfexp(log_gamma_srv2);
  a50_srv2=mfexp(log_a50_srv2);
  for (j=1; j<=nages; j++)
    {
    sel_srv2(j)=(1./(1.-gamma_srv2))*pow((1.-gamma_srv2)/gamma_srv2,
                gamma_srv2)*(exp(beta_srv2*gamma_srv2*(a50_srv2-
                double(j)))/(1+exp(beta_srv2*(a50_srv2-double(j)))));
    }
  //sel_srv2/=max(sel_srv2);
  //cout<<"SURVEY2 SELECTIVITY"<<endl;
  //cout<<sel_srv2<<endl;
  //cout<<"MAXIMUM VALUE: "<<max(sel_srv2)<<endl;

  //cout << "END OF GET SELECTIVITY" << endl;


FUNCTION get_mortality
  //COMPUTE TOTAL MORTALITY BY YEAR AND AGE
  //COMPUTE FISHING MORTALITY MATRIX
  for (int i=styr;i<=endyr;i++)
    {
    for (int j=1;j<=nages;j++)
       {
        F(i,j)=sel(j)*mfexp(log_avg_fmort + fmort_dev(i));
       }
    }

  //COMPUTE TOTAL MORTALITY MATRIX
    Z=F+M;

  //COMPUTE SURVIVAL MATRIX
    S=mfexp(-1.0*Z);

  //cout << "END OF GET MORTALITY" << endl;

FUNCTION get_numbers_at_age
  //COMPUTE NUMBERS AT AGE MATRIX
  int itmp;

  //COMPUTE NUMBERS AT AGE IN INITIAL YEAR
  for (int j=1;j<nages;j++)
    {
      itmp=styr+1-j;
      natage(styr,j)=mfexp(mean_log_rec-M*double(j-1)+rec_dev(itmp));
    }
    natage(styr,nages)=mfexp(mean_log_rec-M*(nages-1))/
                       (1. - survival);

  //COMPUTE RECRUITMENT IN SUBSEQUENT YEARS
  for (int i=styr+1;i<=endyr;i++)
```

```
  {
    natage(i,1)=mfexp(mean_log_rec+rec_dev(i));
  }

//COMPUTE NUMBERS AT AGES 2 TO PLUS-GROUP VIA FORWARD PROJECTION
for (i=styr;i< endyr;i++)
  {
     for (j=2;j<=nages;j++)
       {
       natage(i+1)(j)=natage(i)(j-1)*S(i)(j-1);
       }
     natage(i+1,nages)+=natage(i,nages)*S(i,nages);
  }

//COMPUTE VARIABLES DERIVED FROM NUMBERS AT AGE MATRIX
for (i=styr;i<=endyr;i++)
  {

  //COMPUTE PREDICTED AUTUMN SURVEY1 INDEX AND AGE COMPOSITION
   natage_srv1=elem_prod(natage(i),mfexp(-zfrac_srv1*Z(i)));
   totn_srv1(i)=(natage_srv1*sel_srv1);
   pred_srv1(i)=q1*(natage_srv1*elem_prod(sel_srv1,wt));
   pred_p_srv1(i)=elem_prod(sel_srv1,natage_srv1)/totn_srv1(i);

   //COMPUTE PREDICTED SPRING SURVEY2 INDEX AND AGE COMPOSITION
   natage_srv2=elem_prod(natage(i),mfexp(-zfrac_srv2*Z(i)));
   totn_srv2(i)=(natage_srv2*sel_srv2);
   pred_srv2(i)=q2*pow((natage_srv2*elem_prod(sel_srv2,wt)),exp_srv2);
   pred_p_srv2(i)=elem_prod(sel_srv2,natage_srv2)/totn_srv2(i);

   //COMPUTE POPULATION AND SPAWNING AND EXPLOITABLE BIOMASS
   popnbiom(i)=natage(i)*wt;
   natage_spawn=elem_prod(natage(i),mfexp(-zfrac_spawn*Z(i)));
   spawnbiom(i)=natage_spawn*elem_prod(maturity,wt);
   explbiom(i)=natage(i)*elem_prod(sel,wt);

   //COMPUTE PREDICTED CPUE INDEX
   natage_cpue=elem_prod(natage(i),mfexp(-zfrac_cpue*Z(i)));
   pred_cpue(i)=q_cpue*pow(natage_cpue*elem_prod(sel,wt),exp_cpue);

   //COMPUTE RECRUITMENT
   recruitment(i)=mfexp(mean_log_rec+rec_dev(i));

  }

  //COMPUTE ANNUAL SURPLUS PRODUCTION
  for (i=styr;i<endyr;i++)
    {
    surplus_production(i)=explbiom(i+1)-explbiom(i)+catch_bio(i);
    }

  //COMPUTE DEPLETION RATIOS FOR POPULATION AND SPAWNING BIOMASS
  depletion_popnbiom=popnbiom(endyr)/popnbiom(styr);
  depspawn=spawnbiom(endyr)/spawnbiom(styr);
  deppopnbiom63=popnbiom(endyr)/popnbiom(1963);
  depspawn63=spawnbiom(endyr)/spawnbiom(1963);

  //COMPUTE POPULATION AND SPAWNING BIOMASS IN ENDING YEAR
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```
    endbiom=popnbiom(endyr);
    endspawn=spawnbiom(endyr);

    //COMPUTE F AND NUMBERS AT AGE IN ENDING YEAR
    endF=mfexp(log_avg_fmort+fmort_dev(endyr));
    endN=natage(endyr);

  //cout << "END OF GET NUMBERS AT AGE" << endl;

FUNCTION get_catch_at_age
  //COMPUTE CATCH NUMBERS BY YEAR AND AGE
  for (int i=styr; i<=endyr; i++)
  {
    pred_catch(i)=0.;

    //APPLY THE CATCH EQUATION
    for (int j = 1 ; j<= nages; j++)
      {
      catage(i,j) = natage(i,j)*F(i,j)*(1.-S(i,j))/Z(i,j);

      //COMPUTE PREDICTED CATCH BIOMASS
      pred_catch(i)+=catage(i,j)*wt(j);
      }

      //COMPUTE PREDICTED FISHERY AGE COMPOSITION
      pred_p_fish(i)=catage(i)/sum(catage(i));
    }
  //cout << "END OF GET CATCH AT AGE" << endl;


FUNCTION evaluate_the_objective_function
  //COMPUTE THE MODEL LIKELIHOOD (f)
  f=.0;

  //DO THIS WHEN RECRUITMENT DEVIATIONS ARE ESTIMATED (PHASE>2)
  if (active(rec_dev))
    {
    age_like=0.;
    int ii;

    //COMPUTE RECRUITMENT LIKELIHOOD COMPONENT
    rec_like=norm2(rec_dev);
    f+=lambda_recruitment*rec_like;

    //COMPUTE AGE COMPOSITION LIKELIHOODS
    //FISHERY COMPONENT
    for (int i=1; i <= nobs_fish; i++)
      {
      ii=yrs_fish(i);
      for (int j=1; j<=nages; j++)
        {
        if (obs_p_fish(i,1) >= 0.0)
          age_like(1)-
=nsamples_fish*obs_p_fish(i,j)*log(pred_p_fish(ii,j)+1.e-13);
       //cout << "FISHERY AGE: "<<age_like(1) << " " << i << " "<<j<< endl;
        }
      }
      age_like(1)-=offset(1);
```

```
      age_like(1)*=lambda_fishery_age;

    //AUTUMN SURVEY1 COMPONENT
    for (i=1; i <= nobs_srv1; i++)
      {
      ii=yrs_srv1(i);
      for (int j=1; j<=nages; j++)
        {
        if (obs_p_srv1(i,1) >= 0.0)
          age_like(2)-
=nsamples_srv1*obs_p_srv1(i,j)*log(pred_p_srv1(ii,j)+1.e-13);
       //cout << "SURVEY1 AGE: " << age_like(2) << " " << i << " "<<j<< endl;
        }
      }
      age_like(2)-=offset(2);
      age_like(2)*=lambda_srv1_age;

    //SPRING SURVEY2 COMPONENT
    for (i=1; i <= nobs_srv2; i++)
      {
      ii=yrs_srv2(i);
      for (int j=1; j<=nages; j++)
        {
        if (obs_p_srv2(i,1) >= 0.0)
          age_like(3)-
=nsamples_srv2*obs_p_srv2(i,j)*log(pred_p_srv2(ii,j)+1.e-13);
       //cout << "SURVEY2 AGE: " << age_like(3) << " " << i << " "<<j<< endl;
        }
      }
      age_like(3)-=offset(3);
      age_like(3)*=lambda_srv2_age;

      f+=sum(age_like);
    }

  //COMPUTE CPUE INDEX LIKELIHOOD (LOGNORMAL)
  cpue_like=norm2(log(obs_cpue+0.001)-log(pred_cpue(yrs_cpue)+0.001));
  f+=lambda_fishery_cpue*cpue_like;

  //COMPUTE AUTUMN SURVEY INDEX LIKELIHOOD (LOGNORMAL)
  srv1_like=norm2(log(obs_srv1+0.001)-log(pred_srv1(yrs_srv1)+0.001));
  f+=lambda_biomass_index_srv1*srv1_like;

  //COMPUTE SPRING SURVEY INDEX LIKELIHOOD (LOGNORMAL)
  srv2_like=norm2(log(obs_srv2+0.001)-log(pred_srv2(yrs_srv2)+0.001));
  f+=lambda_biomass_index_srv2*srv2_like;

  //COMPUTE CATCH BIOMASS LIKELIHOOD
  catch_like=norm2(log(catch_bio+0.000001)-log(pred_catch+0.000001));
  f+=lambda_catch_biomass*catch_like;

  //COMPUTE SELECTIVITY LIKELIHOODS
  //FISHERY COMPONENT
  sel_like(1)=norm2(first_difference(first_difference(log_sel_fish)));
  f+=lambda_fishery_sel*square(avgsel_fish);

  //SURVEY COMPONENTS (PLACEHOLDERS FOR FUTURE USE)
  sel_like(2)=0.;
```

```
  sel_like(3)=0.;

  f+=lambda_fishery_sel*sel_like(1);

  //COMPUTE F PENALTY LIKELIHOOD CONSTRAINT
  //HIGH PENALTY IF ESTIMATION PHASE < 3
  //LOW PENALTY IF ESTIMATION PHASE >= 3
  if (current_phase()<3)
    {
     fpen=10.*norm2(mfexp(fmort_dev+log_avg_fmort)-.1);
    }
  else
    {
     fpen=0.001*norm2(mfexp(fmort_dev+log_avg_fmort)-.1);
    }
  if (active(fmort_dev))
    {
     fpen+=norm2(fmort_dev);
    }
  f+=lambda_f_penalty*fpen;


REPORT_SECTION
  //OUTPUT RESULTS TO FILE "RED.REP"

  report << "Redfish Age-structured Model RED" << endl;

  report << "Estimated Numbers (000s) of Fish at Age (year,age)" << endl;
  report << natage << endl;
  report << "Estimated Fishing Mortality (year,age)" << endl;
  report << F << endl;

  report << "Observed Fishery CPUE (year)" << endl;
  report << yrs_cpue << endl;
  report << obs_cpue << endl;
  report << "Predicted Fishery CPUE (year)" << endl;
  report << pred_cpue << endl;
  report << "Residuals for Fishery CPUE (year)" << endl;
  report << obs_cpue - pred_cpue(yrs_cpue) << endl;

  report << "Observed Survey1 Biomass Index (year)" << endl;
  report << yrs_srv1 << endl;
  report << obs_srv1 << endl;
  report << "Predicted Survey1 Biomass Index (year)" << endl;
  report << pred_srv1 << endl;
  report << "Residuals for Survey1 Biomass Index (year)" << endl;
  report << obs_srv1 - pred_srv1(yrs_srv1) << endl;

  report << "Observed Survey2 Biomass Index (year)" << endl;
  report << obs_srv2 << endl;
  report << "Predicted Survey2 Biomass Index (year)" << endl;
  report << pred_srv2 << endl;
  report << "Residuals for Survey2 Biomass Index (year)" << endl;
  report << obs_srv2 - pred_srv2(yrs_srv2) << endl;

  report << "Observed Fishery Proportion at Age (year,age)" << endl;
  report << obs_p_fish << endl;
  report << "Predicted Fishery Proportion at Age (year,age)" << endl;
```

```
  report << pred_p_fish << endl;

  report << "Observed Survey1 Proportion at Age (year,age)" << endl;
  report << obs_p_srv1<< endl;
  report << "Predicted Survey1 Proportion at Age (year,age)" << endl;
  report << pred_p_srv1<< endl;

  report << "Observed Survey2 Proportion at Age (year,age)" << endl;
  report << obs_p_srv2<< endl;
  report << "Predicted Survey2 Proportion at Age (year,age)" << endl;
  report << pred_p_srv2<< endl;

  report << "Population Biomass (mt) by Year"<< endl;
  report << years << endl;
  report << popnbiom << endl;
  report << "Population Biomass in 2000" << endl;
  report << endbiom << endl;
  report << "Depletion ratio in 2000 for population biomass" << endl;
  report << depletion_popnbiom << endl;
  report << "Depletion ratio in 2000 relative to 1963 population biomass" <<
endl;
  report << deppopnbiom63 << endl;

  report << "Spawning Biomass (mt) by Year" << endl;
  report << years << endl;
  report << spawnbiom << endl;
  report << "Spawning Biomass in 2000" << endl;
  report << endspawn << endl;
  report << "Depletion ratio in 2000 for spawning biomass" << endl;
  report << depspawn << endl;
  report << "Depletion ratio in 2000 relative to 1963 spawning biomass" <<
endl;
  report << depspawn63 << endl;

  report << "Exploitable Biomass (mt) by Year"<< endl;
  report << years << endl;
  report << explbiom << endl;

  report << "Population numbers at age (thousands) in 2000" << endl;
  report << ages << endl;
  report << endN << endl;

  report << "Recruitment (thousands of age-1 recruits) by Year" << endl;
  report << rec_years << endl;
  report << mfexp(mean_log_rec+rec_dev) << endl;

  report << "Observed Catch Biomass (mt) by Year" << endl;
  report << years << endl;
  report << catch_bio << endl;
  report << "Predicted Catch Biomass (mt) by Year" << endl;
  report << pred_catch << endl;
  report << "Residuals for Catch Biomass (year)" << endl;
  report << catch_bio - pred_catch << endl;

  report << "Annual Surplus Production (mt)" << endl;
  report << years << endl;
  report << surplus_production << endl;
```

```
  report << "Estimated Average Annual Fishing Mortality by Year" << endl;
  report << years << endl;
  report << mfexp(log_avg_fmort+fmort_dev) << endl;
  report << "Fishing Mortality in 2000" << endl;
  report << endF << endl;

  report << "Fishery Selectivity by Age" << endl;
  report << ages << endl;
  report << sel << endl;

  report << "Survey1 Selectivity by Age" << endl;
  report << ages << endl;
  report << sel_srv1 << endl;

  report << "Survey2 Selectivity by Age" << endl;
  report << ages << endl;
  report << sel_srv2 << endl;

  report << "OBJECTIVE FUNCTION VALUE: " << f << endl;

  report << "LIKELIHOOD EMPHASIS FACTORS" << endl;
  report<< "RECRUITMENT::FISHERY AGE::SURVEY1 AGE::SURVEY2 AGE::F
PENALTY"<<endl;
  report << lambda_recruitment<<"  "<< lambda_fishery_age<< "
"<<lambda_srv1_age<< " "<<lambda_srv2_age<< " "<<lambda_f_penalty<<endl;
  report<< "FISHERY SELECTIVITY::CATCH BIOMASS::CPUE::SURVEY1 INDEX::SURVEY2
INDEX"<<endl;
  report << lambda_fishery_sel<<" "<<lambda_catch_biomass<<"
"<<lambda_fishery_cpue<<" "<<lambda_biomass_index_srv1<<"
"<<lambda_biomass_index_srv1<<endl;

  report << "LIKELIHOOD COMPONENTS" << endl;
  report<< "RECRUITMENT::FISHERY AGE::SURVEY1 AGE::SURVEY2 AGE::F
PENALTY"<<endl;
  report << rec_like<<"  "<< age_like<< " "<<fpen<<endl;
  report<< "FISHERY SELECTIVITY::CATCH BIOMASS::CPUE::SURVEY1 INDEX::SURVEY2
INDEX"<<endl;
  report << sel_like(1)+square(avgsel_fish)<<" "<<catch_like<<"
"<<cpue_like<<" "<<srv1_like<<" "<<srv2_like<<endl;

  //END OF MODEL
```

Part B. AD model builder input data file for the baseline redfish model

```
#Styr endyr
1934 2000
# Number of age classes
26
# Number of age classes for selectivity estimation
9
# Catch biomass:1934 to 2000, n=67
519     7549    23162   14823   20640   25406   26762   50796   55892   48348
50439   37912   42423   40160   43631   30743   34307   30077   21377   16791
12988   13914   14388   18490   16047   15521   11375   14101   14134   10046
8313    8057    8569    10864   6777    12455   16741   20034   19095   17360
10471   10572   10696   13223   14083   14755   10183   7915    6903    5328
4793    4282    2929    1894    1177    637     601     525     849     800
440     440     322     251     320     353     319
```

```
# Number of years of fishery CPUE data
38
# Years of fishery CPUE data
1952 1953 1954 1955 1956 1957 1958 1959 1960 1961 1962 1963 1964 1965 1966
1967 1968 1969 1970 1971 1972 1973 1974 1975 1976 1977 1978 1979 1980 1981
1982 1983 1984 1985 1986 1987 1988 1989
# Fraction of Z Prior to CPUE (fraction of year)
0.50
# Untransformed CPUE biomass index
3.4     3.6     3.1     4.0       3.8     3.6     3.6     3.5     3.0
3.5     4.0       3.0       2.9     4.4     6.4     5.6     6.1     4.9
4.0       3.2     2.9     2.9     2.6     2.2     2.3     2.5     2.4     1.9
  1.6     1.4     1.5     1.2     1.1     0.9     0.6     0.7     0.5     0.6

# Number years of fishery age data
17
# Years of age fishery data
1969 1970 1971 1972 1973 1974 1975 1976 1977 1978 1979 1980 1981 1982 1983
1984 1985
# Number of age samples in fishery (nsamples_fish)
200
# Fishery age composition data 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
20 21 22 23 24 25 26+
0 0 0.0000  0.0006  0.0111  0.0115  0.0265  0.1594  0.0660  0.1765  0.0699
0.1045  0.0864  0.0584  0.0741  0.0354  0.0197  0.0138  0.0159  0.0112  0.0119
0.0091  0.0123  0.0010  0.0026  0.0223
0 0 0.0000  0.0000  0.0027  0.0741  0.0740  0.0194  0.1772  0.0589  0.1526
0.0500  0.0859  0.0488  0.0421  0.0638  0.0325  0.0300  0.0072  0.0121  0.0067
0.0097  0.0105  0.0089  0.0012  0.0319
0 0 0.0000  0.0000  0.0000  0.0014  0.0376  0.0859  0.0298  0.1533  0.0536
0.1261  0.0599  0.0827  0.0713  0.0561  0.0428  0.0536  0.0261  0.0225  0.0109
0.0203  0.0108  0.0055  0.0027  0.0473
0 0 0.0000  0.0000  0.0000  0.0000  0.0196  0.0692  0.1554  0.0360  0.1592
0.0584  0.0606  0.0419  0.0742  0.0514  0.0253  0.0268  0.0471  0.0154  0.0212
0.0246  0.0151  0.0113  0.0269  0.0604
0 0 0.0000  0.0000  0.0000  0.0000  0.0050  0.0523  0.1685  0.1781  0.0467
0.1558  0.0441  0.0658  0.0504  0.0430  0.0382  0.0293  0.0183  0.0198  0.0087
0.0125  0.0090  0.0063  0.0061  0.0420
0 0 0.0122  0.0042  0.0000  0.0007  0.0003  0.0069  0.0748  0.1874  0.1168
0.0966  0.0678  0.0442  0.0517  0.0371  0.0577  0.0361  0.0254  0.0262  0.0234
0.0290  0.0108  0.0113  0.0099  0.0696
0 0 0.0002  0.0294  0.0030  0.0005  0.0000  0.0013  0.0052  0.0822  0.1844
0.0911  0.0817  0.0610  0.0427  0.0569  0.0575  0.0522  0.0400  0.0472  0.0257
0.0375  0.0208  0.0124  0.0126  0.0542
0 0 0.0000  0.0065  0.2986  0.0146  0.0000  0.0000  0.0007  0.0016  0.0156
0.0902  0.1125  0.0567  0.0575  0.0463  0.0411  0.0389  0.0475  0.0203  0.0256
0.0227  0.0108  0.0224  0.0031  0.0670
0 0 0.0000  0.0000  0.0061  0.4335  0.0081  0.0000  0.0000  0.0000  0.0021
0.0551  0.0327  0.1039  0.0472  0.0711  0.0379  0.0308  0.0275  0.0119  0.0183
0.0140  0.0030  0.0148  0.0262  0.0558
0 0 0.0000  0.0000  0.0000  0.0064  0.5767  0.0050  0.0000  0.0008  0.0008
0.0043  0.0396  0.0348  0.0692  0.0410  0.0307  0.0203  0.0211  0.0301  0.0210
0.0172  0.0117  0.0045  0.0124  0.0521
0 0 0.0000  0.0000  0.0006  0.0051  0.0211  0.5911  0.0038  0.0029  0.0012
0.0042  0.0135  0.0306  0.0491  0.0324  0.0394  0.0245  0.0210  0.0251  0.0199
0.0148  0.0133  0.0134  0.0106  0.0624
```

```
0 0 0.0000  0.0000  0.0000  0.0049  0.0065  0.0412  0.6266  0.0077  0.0016
0.0017  0.0080  0.0182  0.0308  0.0453  0.0319  0.0246  0.0209  0.0168  0.0175
0.0137  0.0129  0.0109  0.0098  0.0485
0 0 0.0012  0.0000  0.0039  0.0020  0.0029  0.0024  0.0114  0.6313  0.0043
0.0011  0.0000  0.0022  0.0162  0.0186  0.0650  0.0258  0.0272  0.0202  0.0162
0.0194  0.0156  0.0166  0.0178  0.0785
0 0 0.0002  0.0190  0.0086  0.0042  0.0064  0.0021  0.0000  0.0011  0.5091
0.0039  0.0022  0.0015  0.0090  0.0130  0.0408  0.0317  0.0588  0.0227  0.0351
0.0339  0.0211  0.0094  0.0073  0.1590
0 0 0.0000  0.0010  0.1464  0.0138  0.0040  0.0037  0.0075  0.0043  0.0122
0.4302  0.0050  0.0092  0.0056  0.0036  0.0074  0.0277  0.0234  0.0478  0.0147
0.0194  0.0272  0.0169  0.0114  0.1576
0 0 0.0033  0.0008  0.0037  0.4813  0.0000  0.0014  0.0029  0.0000  0.0025
0.0011  0.2575  0.0000  0.0032  0.0035  0.0025  0.0066  0.0151  0.0120  0.0234
0.0155  0.0104  0.0113  0.0117  0.1303
0 0 0.0026  0.0143  0.0032  0.0030  0.3734  0.0000  0.0027  0.0011  0.0013
0.0039  0.0012  0.3131  0.0000  0.0024  0.0011  0.0099  0.0113  0.0254  0.0225
0.0183  0.0193  0.0139  0.0105  0.1456
# Number of Years: Survey1
38
# Survey1 years
1963 1964 1965 1966 1967 1968 1969 1970 1971 1972 1973 1974 1975 1976 1977
1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992
1993 1994 1995 1996 1997 1998 1999 2000
# Fraction of Z Prior to Survey1 (fraction of year)
0.75
# Survey1 biomass index
493.1101        1117.1706       268.0391        595.4151        497.2023
826.6244        480.8335        673.1669        478.7874        503.3406
347.837 495.1562        816.3939        313.0533        353.9753
423.5427        327.376 257.8086        249.6242        69.5674 83.8901
79.7979 116.6277        163.688 112.5355        128.9043        139.1348
249.6242        171.8724        165.611334      229.122278      121.517879
95.205033       626.781813      387.53134       649.02292       467.820304
 536.078
# Number of age samples in survey1 (nsamples_srv1)
100
# Survey1 age composition data
-99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99
      -99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99
      -99
-99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99
      -99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99
      -99
-99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99
      -99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99
      -99
-99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99
      -99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99
      -99
-99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99
      -99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99
      -99
-99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99
      -99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99
      -99
```

```
-99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99
      -99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99
      -99
-99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99
      -99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99
      -99
-99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99
      -99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99
      -99
-99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99
      -99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99
      -99
-99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99
      -99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99
      -99
-99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99
      -99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99
      -99
0.0000      0.0001      0.0085      0.2724      0.0023      0.0025      0.0000
      0.0000      0.0000      0.0135      0.0173      0.0996      0.0382
      0.0829      0.0436      0.0461      0.0298      0.0176      0.0216
      0.0120      0.0529      0.0195      0.0231      0.0271      0.0181
      0.1514
0.0000      0.0000      0.0020      0.0168      0.3159      0.0048      0.0000
      0.0000      0.0000      0.0000      0.0311      0.0049      0.0880
      0.0449      0.0415      0.0576      0.0358      0.0341      0.0285
      0.0206      0.0029      0.0586      0.0000      0.0106      0.0155
      0.1859
0.0000      0.0020      0.0007      0.0006      0.0319      0.5005      0.0014
      0.0000      0.0000      0.0000      0.0000      0.0201      0.0259
      0.0774      0.0366      0.0301      0.0146      0.0147      0.0127
      0.0151      0.0166      0.0083      0.0314      0.0087      0.1509
      0.0000
0.0003      0.0001      0.0041      0.0020      0.0069      0.0732      0.5333
      0.0032      0.0000      0.0015      0.0023      0.0126      0.0616
      0.0434      0.0318      0.0269      0.0207      0.0100      0.0237
      0.0160      0.0113      0.0114      0.0227      0.0088      0.0131
      0.0589
0.0033      0.0000      0.0022      0.0069      0.0022      0.0095      0.0387
      0.5368      0.0012      0.0013      0.0012      0.0062      0.0123
      0.0222      0.0453      0.0614      0.0238      0.0323      0.0223
      0.0155      0.0290      0.0187      0.0128      0.0050      0.0039
      0.0860
0.0014      0.0403      0.0019      0.0049      0.0208      0.0145      0.0078
      0.0222      0.4781      0.0026      0.0000      0.0000      0.0026
      0.0020      0.0142      0.0691      0.0365      0.0258      0.0382
      0.0184      0.0115      0.0303      0.0137      0.0153      0.0213
      0.1066
0.0000      0.0062      0.0431      0.0123      0.0015      0.0124      0.0042
      0.0074      0.0416      0.2958      0.0084      0.0183      0.0231
      0.0239      0.0187      0.0468      0.0282      0.1701      0.0123
      0.0339      0.0252      0.0198      0.0166      0.0153      0.0208
      0.0940
0.0000      0.0033      0.0064      0.4456      0.0451      0.0000      0.0000
      0.0020      0.0133      0.0183      0.2467      0.0105      0.0089
      0.0039      0.0066      0.0166      0.0378      0.0188      0.0331
      0.0038      0.0077      0.0096      0.0077      0.0096      0.0052
      0.0394
```

0.0015 0.0250 0.0308 0.0343 0.4121 0.0163 0.0052
0.0076 0.0120 0.0238 0.0250 0.2443 0.0058
0.0055 0.0073 0.0121 0.0141 0.0120 0.0177
0.0031 0.0056 0.0142 0.0121 0.0095 0.0072
0.0360
0.0052 0.0509 0.0330 0.0274 0.0035 0.3223 0.0043
0.0070 0.0027 0.0035 0.0039 0.0000 0.4073
0.0000 0.0039 0.0000 0.0099 0.0041 0.0023
0.0000 0.0897 0.0000 0.0017 0.0023 0.0017
0.0137
0.0000 0.0140 0.1024 0.1178 0.0277 0.0242 0.2419
0.0139 0.0000 0.0303 0.0000 0.0541 0.0033
0.2339 0.0015 0.0109 0.0000 0.0111 0.0022
0.0049 0.0043 0.0830 0.0000 0.0106 0.0000
0.0080
0.0000 0.0000 0.0108 0.2161 0.3510 0.0197 0.0000
0.1921 0.0034 0.0004 0.0057 0.0025 0.0057
0.0047 0.1472 0.0000 0.0008 0.0000 0.0010
0.0027 0.0000 0.0000 0.0268 0.0000 0.0007
0.0087
0.0000 0.0119 0.0461 0.0502 0.2591 0.1388 0.0057
0.0061 0.1637 0.0000 0.0027 0.0066 0.0037
0.0037 0.0023 0.2074 0.0036 0.0037 0.0000
0.0021 0.0016 0.0055 0.0030 0.0634 0.0000
0.0092
0.0299 0.0904 0.0334 0.0595 0.0198 0.1900 0.1144
0.0063 0.0000 0.1856 0.0000 0.0000 0.0051
0.0102 0.0041 0.0092 0.1856 0.0000 0.0000
0.0012 0.0000 0.0000 0.0000 0.0000 0.0392
0.0160
0.0031 0.0450 0.1682 0.1314 0.0440 0.0274 0.2423
0.0503 0.0000 0.0063 0.1317 0.0000 0.0000
0.0018 0.0092 0.0027 0.0028 0.0630 0.0000
0.0018 0.0076 0.0110 0.0064 0.0000 0.0015
0.0423
0.0063 0.0070 0.0253 0.1055 0.3132 0.1092 0.0454
0.0759 0.0695 0.0223 0.0014 0.0819 0.0000
0.0000 0.0090 0.0048 0.0070 0.0015 0.0587
0.0000 0.0073 0.0010 0.0035 0.0000 0.0034
0.0409
0.0106 0.0059 0.0184 0.0558 0.2403 0.1495 0.0614
0.0379 0.0965 0.0432 0.0240 0.0000 0.1097
0.0051 0.0059 0.0000 0.0121 0.0101 0.0037
0.0666 0.0000 0.0051 0.0000 0.0089 0.0000
0.0294
0.0089 0.0100 0.0256 0.0881 0.1258 0.1779 0.1768
0.0519 0.0335 0.0557 0.0392 0.0143 0.0168
0.0861 0.0000 0.0112 0.0027 0.0081 0.0099
0.0000 0.0317 0.0000 0.0041 0.0025 0.0000
0.0190
0.0101 0.0294 0.0531 0.1174 0.1520 0.1935 0.1263
0.1162 0.0252 0.0255 0.0345 0.0156 0.0177
0.0000 0.0407 0.0018 0.0000 0.0019 0.0030
0.0014 0.0000 0.0175 0.0000 0.0000 0.0000
0.0173
0.0184 0.0466 0.0949 0.1340 0.1052 0.1212 0.1074
0.1308 0.0725 0.0306 0.0198 0.0374 0.0106
0.0016 0.0000 0.0427 0.0000 0.0000 0.0009

```
      0.0008      0.0015      0.0000      0.0176      0.0000      0.0000
      0.0056
0.0061      0.0299      0.1631      0.5279      0.0875      0.0570      0.0280
      0.0221      0.0298      0.0073      0.0074      0.0026      0.0027
      0.0086      0.0000      0.0000      0.0120      0.0000      0.0000
      0.0000      0.0000      0.0000      0.0000      0.0028      0.0000
      0.0051
0.0003      0.0006      0.0114      0.3269      0.4075      0.0770      0.0695
      0.0504      0.0048      0.0110      0.0189      0.0027      0.0028
      0.0029      0.0038      0.0000      0.0000      0.0052      0.0000
      0.0003      0.0007      0.0000      0.0000      0.0000      0.0015
      0.0017
0.0051      0.0015      0.0216      0.0725      0.2734      0.2226      0.0642
      0.0540      0.0576      0.0373      0.0276      0.0760      0.0047
      0.0177      0.0111      0.0091      0.0050      0.0021      0.0185
      0.0009      0.0000      0.0025      0.0001      0.0024      0.0000
      0.0126
0.0022      0.0007      0.0079      0.0274      0.1177      0.3412      0.2411
      0.0717      0.0602      0.0458      0.0337      0.0074      0.0215
      0.0000      0.0029      0.0069      0.0015      0.0000      0.0000
      0.0078      0.0000      0.0004      0.0006      0.0000      0.0000
      0.0014
-99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99
      -99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99
      -99
-99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99
      -99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99
      -99
# Number of Years: Survey2
33
# Survey2 years
1968 1969 1970 1971 1972 1973 1974 1975 1976 1977 1978 1979 1980 1981 1982
1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997
1998 1999 2000
# Fraction of Z Prior to Survey2 (fraction of year)
0.25
# Survey2 biomass index
347.837 403.0817        386.7129        1465.0076       908.4684
517.6633        384.6668        360.1136        536.0782        237.3476
249.6242        660.8903        415.3583        380.5746        192.3334
124.8121        55.2447 135.0426        65.4752 263.9469        67.5213
59.3369 139.1348        87.9823 218.31887       358.0675        80.20712
39.28512        243.28129       696.49244       160.41424       389.16822
1146.02
# Number of age samples in survey2 (nsamples_srv2)
100
# Survey2 age composition data
-99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99
      -99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99
      -99
-99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99
      -99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99
      -99
-99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99
      -99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99
      -99
```

```
-99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99
      -99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99
      -99
-99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99
      -99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99
      -99
-99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99
      -99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99
      -99
-99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99
      -99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99
      -99
0.0000      0.0000      0.0151      0.2174      0.0080      0.0161      0.0080
      0.0000      0.0000      0.0342      0.0140      0.0899      0.0445
      0.1262      0.0413      0.0682      0.0453      0.0242      0.0215
      0.0267      0.0469      0.0149      0.0207      0.0032      0.0107
      0.1031
0.0000      0.0000      0.0010      0.0329      0.0229      0.0034      0.0105
      0.0021      0.0150      0.0033      0.0622      0.0218      0.1676
      0.1320      0.0464      0.0759      0.0594      0.0162      0.0253
      0.0285      0.0218      0.0780      0.0004      0.0183      0.0176
      0.1375
0.0000      0.0000      0.0008      0.0027      0.0548      0.0717      0.0147
      0.0019      0.0000      0.0023      0.0037      0.0368      0.0309
      0.1327      0.0604      0.0622      0.0463      0.0513      0.0162
      0.0278      0.0281      0.0189      0.0520      0.0223      0.0289
      0.2324
0.0000      0.0000      0.0089      0.0026      0.0005      0.0267      0.4146
      0.0031      0.0016      0.0000      0.0029      0.0110      0.0740
      0.0373      0.0412      0.0253      0.0396      0.0268      0.0328
      0.0170      0.0299      0.0278      0.0203      0.0150      0.0200
      0.1208
0.0000      0.0004      0.0001      0.0002      0.0015      0.0055      0.0093
      0.5378      0.0000      0.0000      0.0051      0.0136      0.0244
      0.0503      0.0375      0.0327      0.0402      0.0343      0.0202
      0.0182      0.0187      0.0354      0.0121      0.0068      0.0167
      0.0790
0.0000      0.0034      0.0026      0.0000      0.0036      0.0000      0.0000
      0.0050      0.4086      0.0000      0.0057      0.0024      0.0000
      0.0091      0.0200      0.0731      0.0650      0.0528      0.0389
      0.0424      0.0259      0.0397      0.0386      0.0108      0.0163
      0.1363
-99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99
      -99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99
      -99
-99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99
      -99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99
      -99
-99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99
      -99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99   -99
      -99
0.0000      0.0066      0.0344      0.0129      0.0000      0.2546      0.0029
      0.0000      0.0033      0.0123      0.0100      0.0000      0.4611
      0.0000      0.0000      0.0000      0.0055      0.0000      0.0029
      0.0000      0.1862      0.0000      0.0000      0.0000      0.0000
      0.0074
0.0000      0.0040      0.0178      0.0608      0.0133      0.0000      0.2764
      0.0000      0.0000      0.0124      0.0000      0.0165      0.0055
```

```
     0.3921     0.0039     0.0039     0.0000     0.0000     0.0017
     0.0000     0.0026     0.1531     0.0000     0.0000     0.0077
     0.0283
0.0000     0.0000     0.0000     0.0111     0.0747     0.0177     0.0091
     0.2037     0.0054     0.0050     0.0123     0.0016     0.0179
     0.0105     0.4224     0.0036     0.0036     0.0111     0.0089
     0.0020     0.0034     0.0081     0.1187     0.0131     0.0056
     0.0306
0.0000     0.0000     0.0000     0.0048     0.0549     0.1204     0.0057
     0.0041     0.2703     0.0000     0.0000     0.0000     0.0035
     0.0000     0.0055     0.3953     0.0000     0.0059     0.0000
     0.0320     0.0000     0.0172     0.0000     0.0695     0.0000
     0.0110
0.0070     0.0243     0.0273     0.0413     0.0416     0.2168     0.1646
     0.0215     0.0054     0.2054     0.0000     0.0039     0.0110
     0.0029     0.0132     0.0039     0.1589     0.0000     0.0000
     0.0029     0.0099     0.0029     0.0015     0.0000     0.0303
     0.0035
0.0000     0.0431     0.1388     0.0859     0.0805     0.0645     0.1898
     0.0807     0.0061     0.0048     0.1558     0.0000     0.0151
     0.0030     0.0124     0.0101     0.0026     0.0780     0.0000
     0.0000     0.0000     0.0041     0.0000     0.0024     0.0000
     0.0225
0.0000     0.0000     0.0000     0.0141     0.0815     0.0375     0.0197
     0.1127     0.0850     0.0419     0.0105     0.2091     0.0149
     0.0151     0.0052     0.0262     0.0195     0.0000     0.1692
     0.0000     0.0035     0.0035     0.0166     0.0000     0.0031
     0.1111
-99  -99  -99  -99  -99  -99  -99  -99  -99  -99  -99  -99  -99
     -99  -99  -99  -99  -99  -99  -99  -99  -99  -99  -99  -99
     -99
-99  -99  -99  -99  -99  -99  -99  -99  -99  -99  -99  -99  -99
     -99  -99  -99  -99  -99  -99  -99  -99  -99  -99  -99  -99
     -99
-99  -99  -99  -99  -99  -99  -99  -99  -99  -99  -99  -99  -99
     -99  -99  -99  -99  -99  -99  -99  -99  -99  -99  -99  -99
     -99
-99  -99  -99  -99  -99  -99  -99  -99  -99  -99  -99  -99  -99
     -99  -99  -99  -99  -99  -99  -99  -99  -99  -99  -99  -99
     -99
-99  -99  -99  -99  -99  -99  -99  -99  -99  -99  -99  -99  -99
     -99  -99  -99  -99  -99  -99  -99  -99  -99  -99  -99  -99
     -99
-99  -99  -99  -99  -99  -99  -99  -99  -99  -99  -99  -99  -99
     -99  -99  -99  -99  -99  -99  -99  -99  -99  -99  -99  -99
     -99
-99  -99  -99  -99  -99  -99  -99  -99  -99  -99  -99  -99  -99
     -99  -99  -99  -99  -99  -99  -99  -99  -99  -99  -99  -99
     -99
-99  -99  -99  -99  -99  -99  -99  -99  -99  -99  -99  -99  -99
     -99  -99  -99  -99  -99  -99  -99  -99  -99  -99  -99  -99
     -99
-99  -99  -99  -99  -99  -99  -99  -99  -99  -99  -99  -99  -99
     -99  -99  -99  -99  -99  -99  -99  -99  -99  -99  -99  -99
     -99
-99  -99  -99  -99  -99  -99  -99  -99  -99  -99  -99  -99  -99
     -99  -99  -99  -99  -99  -99  -99  -99  -99  -99  -99  -99
     -99
```

```
# Weight at age 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
25 26+
0.010 0.020 0.059 0.099 0.145 0.178 0.201 0.250 0.272 0.310 0.348 0.391 0.423
      0.429 0.463 0.495 0.503 0.508 0.548 0.558 0.565 0.581 0.595 0.583 0.582
      0.637
# Fraction of Z Prior to Survey2 (fraction of year)
0.4
# Maturity at age 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
24 25 26+
0.01 0.02 0.05 0.15 0.36 0.64 0.85 0.95 0.98 0.99 1.0 1.0 1.0 1.0 1.0 1.0 1.0
1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0
# Likelihood emphasis: recruitment
10.0
# Likelihood emphasis: fishery CPUE
10.0
# Likelihood emphasis: fishery age composition
10.0
# Likelihood emphasis: survey1 age composition
1.0
# Likelihood emphasis: survey1 biomass index
1000.0
# Likelihood emphasis: survey2 age composition
1.0
# Likelihood emphasis: survey2 biomass index
1000.0
# Likelihood emphasis: catch biomass
1000.0
# Likelihood emphasis: fishery selectivity
100.0
# Likelihood emphasis: F penalty
1.0
```

Part C. Parameter estimates for the baseline redfish model

```
# Number of parameters = 180  Objective function value = 59085.6
Maximum gradient component = 0.00504383
# M:
0.0500000
# mean_log_rec:
10.2724
# rec_dev:
 0.268855 0.283947 0.297777 0.314857 0.333105 0.350796 0.369690
0.387451 0.403300 0.420083 0.440757 0.464639 0.483848 0.501822
0.518171 0.529029 0.535958 0.539225 0.537752 0.532906 0.520225
0.503848 0.483875 0.453279 0.422725 0.390453 0.356663 0.322604
0.280342 0.241802 0.186877 0.131817 4.41036 0.0730586 0.0447724
0.177915 -0.0599116 0.739315 1.09719 0.752359 0.721279 0.740825
0.551414 0.940173 0.999282 0.893913 0.763189 0.821884 0.879004
0.537755 0.876231 0.361673 1.04706 0.460299 1.21943 1.01003 0.181569
-1.29956 -1.88507 -2.37217 -2.33104 -1.95963 2.15325 -1.45054 -2.39424
-2.67683 -2.80352 -2.92961 -2.59663 0.631947 -2.41794 -2.27252 -1.19573
-0.457794 -1.17594 -0.363761 -0.730176 -1.73081 -2.09661 -1.11887 1.03656
-1.13811 -0.138773 0.959950 2.88905 -0.408892 -0.419690 -0.318368 -0.106372
0.0321912 0.0377070
# q_cpue:
0.237518
# exp_cpue:
1.02686
```

```
# q1:
0.433081
# log_gamma_srv1:
-26.4739
# log_beta_srv1:
1.64018
# log_a50_srv1:
0.899916
# q2:
0.269453
# exp_srv2:
1.13955
# log_gamma_srv2:
-2.69852
# log_beta_srv2:
0.912254
# log_a50_srv2:
1.98356
# log_avg_fmort:
-2.38105
# fmort_dev:
 -3.88561 -1.21407 -0.0593014 -0.444405 -0.0599694 0.228452
0.384928 1.20714 1.65149 2.02563 3.06284 3.32126 2.21159
1.37306 1.35777 0.864387 0.860784 0.831010 0.560203 0.335825
0.0938184 0.201353 0.233430 0.509311 0.422418 0.430442
0.116242 0.336893 0.356479 0.0151891 -0.185709 -0.216506
-0.211847 -0.00849619 -0.530360 -0.0220489 0.178860 0.427356
0.510032 0.529555 0.142097 0.261029 0.446245 0.694902 0.847007
1.11955 0.920498 0.976525 1.09685 0.764003 0.579625 0.573149
0.239577 -0.122847 -0.604619 -1.26892 -1.41317 -1.60553
-1.13971 -1.22792 -1.93687 -2.06806 -2.47179 -2.90879 -2.98155 -3.21671 -
3.49401
# log_selcoffs_fish:
 -6.66942 -5.04366 -3.42745 -1.87496 -0.472954 0.367989 0.593606 0.763784
1.02302
```

Part D. Standard deviation estimates for the baseline redfish model

index	name	value	std dev
1	mean_log_rec	1.0272e+01	1.4742e-02
2	rec_dev	2.6885e-01	2.5312e-01
3	rec_dev	2.8395e-01	2.5553e-01
4	rec_dev	2.9778e-01	2.5780e-01
5	rec_dev	3.1486e-01	2.6068e-01
6	rec_dev	3.3311e-01	2.6385e-01
7	rec_dev	3.5080e-01	2.6704e-01
8	rec_dev	3.6969e-01	2.7056e-01
9	rec_dev	3.8745e-01	2.7398e-01
10	rec_dev	4.0330e-01	2.7715e-01
11	rec_dev	4.2008e-01	2.8061e-01
12	rec_dev	4.4076e-01	2.8501e-01
13	rec_dev	4.6464e-01	2.9037e-01
14	rec_dev	4.8385e-01	2.9493e-01
15	rec_dev	5.0182e-01	2.9938e-01
16	rec_dev	5.1817e-01	3.0359e-01
17	rec_dev	5.2903e-01	3.0653e-01
18	rec_dev	5.3596e-01	3.0848e-01
19	rec_dev	5.3922e-01	3.0947e-01

20	rec_dev	5.3775e-01	3.0917e-01
21	rec_dev	5.3291e-01	3.0793e-01
22	rec_dev	5.2023e-01	3.0461e-01
23	rec_dev	5.0385e-01	3.0039e-01
24	rec_dev	4.8387e-01	2.9546e-01
25	rec_dev	4.5328e-01	2.8833e-01
26	rec_dev	4.2273e-01	2.8159e-01
27	rec_dev	3.9045e-01	2.7488e-01
28	rec_dev	3.5666e-01	2.6832e-01
29	rec_dev	3.2260e-01	2.6212e-01
30	rec_dev	2.8034e-01	2.5509e-01
31	rec_dev	2.4180e-01	2.4898e-01
32	rec_dev	1.8688e-01	2.4111e-01
33	rec_dev	1.3182e-01	2.3387e-01
34	rec_dev	4.4104e+00	5.4561e-02
35	rec_dev	7.3059e-02	2.2667e-01
36	rec_dev	4.4772e-02	2.2340e-01
37	rec_dev	1.7792e-01	2.1008e-01
38	rec_dev	-5.9912e-02	1.9343e-01
39	rec_dev	7.3932e-01	1.3464e-01
40	rec_dev	1.0972e+00	9.6926e-02
41	rec_dev	7.5236e-01	9.6297e-02
42	rec_dev	7.2128e-01	8.2512e-02
43	rec_dev	7.4083e-01	7.0654e-02
44	rec_dev	5.5141e-01	6.7518e-02
45	rec_dev	9.4017e-01	5.0120e-02
46	rec_dev	9.9928e-01	4.3512e-02
47	rec_dev	8.9391e-01	4.0973e-02
48	rec_dev	7.6319e-01	3.9513e-02
49	rec_dev	8.2188e-01	3.5459e-02
50	rec_dev	8.7900e-01	3.1787e-02
51	rec_dev	5.3776e-01	3.3825e-02
52	rec_dev	8.7623e-01	2.8416e-02
53	rec_dev	3.6167e-01	3.2249e-02
54	rec_dev	1.0471e+00	2.5424e-02
55	rec_dev	4.6030e-01	3.0990e-02
56	rec_dev	1.2194e+00	2.4601e-02
57	rec_dev	1.0100e+00	2.5843e-02
58	rec_dev	1.8157e-01	3.3159e-02
59	rec_dev	-1.2996e+00	6.0605e-02
60	rec_dev	-1.8851e+00	7.8658e-02
61	rec_dev	-2.3722e+00	9.6087e-02
62	rec_dev	-2.3310e+00	8.9168e-02
63	rec_dev	-1.9596e+00	7.3734e-02
64	rec_dev	2.1533e+00	1.8505e-02
65	rec_dev	-1.4505e+00	5.7869e-02
66	rec_dev	-2.3942e+00	8.3351e-02
67	rec_dev	-2.6768e+00	8.8403e-02
68	rec_dev	-2.8035e+00	8.8833e-02
69	rec_dev	-2.9296e+00	9.1506e-02
70	rec_dev	-2.5966e+00	8.7627e-02
71	rec_dev	6.3195e-01	2.3502e-02
72	rec_dev	-2.4179e+00	9.9245e-02
73	rec_dev	-2.2725e+00	9.6637e-02
74	rec_dev	-1.1957e+00	6.3151e-02
75	rec_dev	-4.5779e-01	5.3984e-02
76	rec_dev	-1.1759e+00	9.8257e-02
77	rec_dev	-3.6376e-01	6.7866e-02

78	rec_dev	-7.3018e-01	7.3664e-02
79	rec_dev	-1.7308e+00	7.5533e-02
80	rec_dev	-2.0966e+00	8.7799e-02
81	rec_dev	-1.1189e+00	1.0655e-01
82	rec_dev	1.0366e+00	3.4310e-02
83	rec_dev	-1.1381e+00	1.0369e-01
84	rec_dev	-1.3877e-01	7.4339e-02
85	rec_dev	9.5995e-01	9.3736e-02
86	rec_dev	2.8891e+00	3.7045e-02
87	rec_dev	-4.0889e-01	1.6864e-01
88	rec_dev	-4.1969e-01	1.8040e-01
89	rec_dev	-3.1837e-01	1.8829e-01
90	rec_dev	-1.0637e-01	2.0653e-01
91	rec_dev	3.2191e-02	2.2190e-01
92	rec_dev	3.7707e-02	2.2252e-01
93	q_cpue	2.3752e-01	1.6228e-01
94	exp_cpue	1.0269e+00	6.0747e-02
95	q1	4.3308e-01	3.8020e-03
96	log_gamma_srv1	-2.6474e+01	7.3724e+03
97	log_beta_srv1	1.6402e+00	6.7084e-02
98	log_a50_srv1	8.9992e-01	1.3036e-02
99	q2	2.6945e-01	2.7187e-02
100	exp_srv2	1.1396e+00	9.2428e-03
101	log_gamma_srv2	-2.6985e+00	3.2973e-02
102	log_beta_srv2	9.1225e-01	1.9160e-02
103	log_a50_srv2	1.9836e+00	2.8834e-03
104	log_avg_fmort	-2.3811e+00	1.5254e-02
105	fmort_dev	-3.8856e+00	3.3472e-02
106	fmort_dev	-1.2141e+00	3.2644e-02
107	fmort_dev	-5.9301e-02	3.2353e-02
108	fmort_dev	-4.4440e-01	3.2756e-02
109	fmort_dev	-5.9969e-02	3.2975e-02
110	fmort_dev	2.2845e-01	3.3947e-02
111	fmort_dev	3.8493e-01	3.5892e-02
112	fmort_dev	1.2071e+00	4.0939e-02
113	fmort_dev	1.6515e+00	5.6966e-02
114	fmort_dev	2.0256e+00	9.8459e-02
115	fmort_dev	3.0628e+00	2.9377e-01
116	fmort_dev	3.3213e+00	1.7008e-01
117	fmort_dev	2.2116e+00	3.6096e-02
118	fmort_dev	1.3731e+00	3.3732e-02
119	fmort_dev	1.3578e+00	3.3118e-02
120	fmort_dev	8.6439e-01	3.4271e-02
121	fmort_dev	8.6078e-01	3.0787e-02
122	fmort_dev	8.3101e-01	3.1657e-02
123	fmort_dev	5.6020e-01	3.2059e-02
124	fmort_dev	3.3583e-01	3.1773e-02
125	fmort_dev	9.3818e-02	3.1120e-02
126	fmort_dev	2.0135e-01	2.9817e-02
127	fmort_dev	2.3343e-01	2.9208e-02
128	fmort_dev	5.0931e-01	2.8586e-02
129	fmort_dev	4.2242e-01	2.8156e-02
130	fmort_dev	4.3044e-01	2.7689e-02
131	fmort_dev	1.1624e-01	2.7701e-02
132	fmort_dev	3.3689e-01	2.7228e-02
133	fmort_dev	3.5648e-01	2.6979e-02
134	fmort_dev	1.5189e-02	2.7083e-02
135	fmort_dev	-1.8571e-01	2.7187e-02

136	fmort_dev	-2.1651e-01	2.7359e-02
137	fmort_dev	-2.1185e-01	2.7017e-02
138	fmort_dev	-8.4962e-03	2.6881e-02
139	fmort_dev	-5.3036e-01	2.6847e-02
140	fmort_dev	-2.2049e-02	2.6148e-02
141	fmort_dev	1.7886e-01	2.5395e-02
142	fmort_dev	4.2736e-01	2.5391e-02
143	fmort_dev	5.1003e-01	2.5633e-02
144	fmort_dev	5.2955e-01	2.5675e-02
145	fmort_dev	1.4210e-01	2.6245e-02
146	fmort_dev	2.6103e-01	2.6446e-02
147	fmort_dev	4.4625e-01	2.7437e-02
148	fmort_dev	6.9490e-01	2.7582e-02
149	fmort_dev	8.4701e-01	2.7505e-02
150	fmort_dev	1.1196e+00	2.7876e-02
151	fmort_dev	9.2050e-01	2.7643e-02
152	fmort_dev	9.7652e-01	2.8618e-02
153	fmort_dev	1.0969e+00	2.8678e-02
154	fmort_dev	7.6400e-01	2.7683e-02
155	fmort_dev	5.7962e-01	2.6796e-02
156	fmort_dev	5.7315e-01	2.7042e-02
157	fmort_dev	2.3958e-01	2.7547e-02
158	fmort_dev	-1.2285e-01	2.8522e-02
159	fmort_dev	-6.0462e-01	2.8535e-02
160	fmort_dev	-1.2689e+00	2.8231e-02
161	fmort_dev	-1.4132e+00	2.8137e-02
162	fmort_dev	-1.6055e+00	2.8094e-02
163	fmort_dev	-1.1397e+00	2.8292e-02
164	fmort_dev	-1.2279e+00	2.8619e-02
165	fmort_dev	-1.9369e+00	2.8233e-02
166	fmort_dev	-2.0681e+00	2.7947e-02
167	fmort_dev	-2.4718e+00	2.7878e-02
168	fmort_dev	-2.9088e+00	2.8105e-02
169	fmort_dev	-2.9815e+00	2.8336e-02
170	fmort_dev	-3.2167e+00	2.9394e-02
171	fmort_dev	-3.4940e+00	2.9754e-02
172	log_selcoffs_fish	-6.6694e+00	2.4589e-01
173	log_selcoffs_fish	-5.0437e+00	1.6381e-01
174	log_selcoffs_fish	-3.4274e+00	1.0990e-01
175	log_selcoffs_fish	-1.8750e+00	8.4252e-02
176	log_selcoffs_fish	-4.7295e-01	7.5597e-02
177	log_selcoffs_fish	3.6799e-01	7.3073e-02
178	log_selcoffs_fish	5.9361e-01	7.2418e-02
179	log_selcoffs_fish	7.6378e-01	7.2433e-02
180	log_selcoffs_fish	1.0230e+00	7.1379e-02
181	spawnbiom	2.8053e+05	8.5828e+03
182	spawnbiom	2.8114e+05	8.4823e+03
183	spawnbiom	2.7111e+05	8.3532e+03
184	spawnbiom	2.5543e+05	8.2028e+03
185	spawnbiom	2.4206e+05	8.0555e+03
186	spawnbiom	2.2341e+05	7.9104e+03
187	spawnbiom	2.0157e+05	7.7750e+03
188	spawnbiom	1.6865e+05	7.6787e+03
189	spawnbiom	1.2073e+05	7.6117e+03
190	spawnbiom	7.4178e+04	7.6393e+03
191	spawnbiom	3.2350e+04	8.7278e+03
192	spawnbiom	3.3190e+04	2.5613e+03
193	spawnbiom	8.1265e+04	1.1524e+03

194	spawnbiom	1.3825e+05	1.8652e+03
195	spawnbiom	1.6172e+05	2.4202e+03
196	spawnbiom	1.7576e+05	2.9492e+03
197	spawnbiom	1.5986e+05	2.8738e+03
198	spawnbiom	1.4673e+05	2.8268e+03
199	spawnbiom	1.3834e+05	2.6914e+03
200	spawnbiom	1.3641e+05	2.5455e+03
201	spawnbiom	1.3534e+05	2.3289e+03
202	spawnbiom	1.3040e+05	1.9940e+03
203	spawnbiom	1.2983e+05	1.8638e+03
204	spawnbiom	1.2707e+05	1.7234e+03
205	spawnbiom	1.2058e+05	1.5079e+03
206	spawnbiom	1.1609e+05	1.3274e+03
207	spawnbiom	1.1684e+05	1.2649e+03
208	spawnbiom	1.1607e+05	1.1550e+03
209	spawnbiom	1.1371e+05	1.0555e+03
210	spawnbiom	1.1320e+05	9.9770e+02
211	spawnbiom	1.1534e+05	9.6451e+02
212	spawnbiom	1.1759e+05	9.3257e+02
213	spawnbiom	1.2009e+05	9.2347e+02
214	spawnbiom	1.2401e+05	9.4346e+02
215	spawnbiom	1.2685e+05	9.5168e+02
216	spawnbiom	1.3167e+05	9.6523e+02
217	spawnbiom	1.3076e+05	9.5698e+02
218	spawnbiom	1.2528e+05	9.2349e+02
219	spawnbiom	1.1463e+05	8.6531e+02
220	spawnbiom	1.0187e+05	7.9818e+02
221	spawnbiom	9.1548e+04	7.5488e+02
222	spawnbiom	8.5609e+04	7.2825e+02
223	spawnbiom	8.3358e+04	7.1061e+02
224	spawnbiom	8.2181e+04	6.9399e+02
225	spawnbiom	7.6385e+04	6.5534e+02
226	spawnbiom	6.8200e+04	5.8212e+02
227	spawnbiom	5.4823e+04	4.9362e+02
228	spawnbiom	4.4925e+04	4.3336e+02
229	spawnbiom	3.6442e+04	3.8463e+02
230	spawnbiom	3.1076e+04	3.6143e+02
231	spawnbiom	2.8623e+04	3.4623e+02
232	spawnbiom	2.6007e+04	3.2754e+02
233	spawnbiom	2.5054e+04	3.2578e+02
234	spawnbiom	2.4335e+04	3.2461e+02
235	spawnbiom	2.4590e+04	3.2475e+02
236	spawnbiom	2.5853e+04	3.2959e+02
237	spawnbiom	2.8238e+04	3.4553e+02
238	spawnbiom	2.9766e+04	3.5285e+02
239	spawnbiom	3.0834e+04	3.5993e+02
240	spawnbiom	3.2526e+04	3.7373e+02
241	spawnbiom	3.5815e+04	3.9726e+02
242	spawnbiom	4.0296e+04	4.3298e+02
243	spawnbiom	4.6209e+04	4.8447e+02
244	spawnbiom	5.8759e+04	5.9829e+02
245	spawnbiom	7.9244e+04	8.1151e+02
246	spawnbiom	1.0785e+05	1.2686e+03
247	spawnbiom	1.3267e+05	1.7057e+03
248	recruitment	4.4138e+04	1.2467e+04
249	recruitment	4.2737e+04	1.1793e+04
250	recruitment	4.1317e+04	1.1137e+04
251	recruitment	3.9933e+04	1.0524e+04

252	recruitment	3.8281e+04	9.8293e+03
253	recruitment	3.6833e+04	9.2378e+03
254	recruitment	3.4865e+04	8.4857e+03
255	recruitment	3.2997e+04	7.8054e+03
256	recruitment	2.3803e+06	1.0019e+05
257	recruitment	3.1114e+04	7.1394e+03
258	recruitment	3.0246e+04	6.8400e+03
259	recruitment	3.4554e+04	7.3462e+03
260	recruitment	2.7240e+04	5.3286e+03
261	recruitment	6.0577e+04	8.2185e+03
262	recruitment	8.6643e+04	8.3992e+03
263	recruitment	6.1373e+04	5.9079e+03
264	recruitment	5.9494e+04	4.8803e+03
265	recruitment	6.0669e+04	4.2304e+03
266	recruitment	5.0200e+04	3.3368e+03
267	recruitment	7.4053e+04	3.5614e+03
268	recruitment	7.8562e+04	3.2172e+03
269	recruitment	7.0705e+04	2.6999e+03
270	recruitment	6.2041e+04	2.2709e+03
271	recruitment	6.5791e+04	2.1101e+03
272	recruitment	6.9659e+04	1.9413e+03
273	recruitment	4.9519e+04	1.4994e+03
274	recruitment	6.9466e+04	1.6632e+03
275	recruitment	4.1524e+04	1.1866e+03
276	recruitment	8.2407e+04	1.6718e+03
277	recruitment	4.5828e+04	1.2396e+03
278	recruitment	9.7908e+04	1.8514e+03
279	recruitment	7.9411e+04	1.6247e+03
280	recruitment	3.4680e+04	1.0199e+03
281	recruitment	7.8856e+03	4.6736e+02
282	recruitment	4.3909e+03	3.4280e+02
283	recruitment	2.6978e+03	2.5913e+02
284	recruitment	2.8111e+03	2.5013e+02
285	recruitment	4.0754e+03	2.9790e+02
286	recruitment	2.4910e+05	2.5040e+03
287	recruitment	6.7806e+03	3.8303e+02
288	recruitment	2.6389e+03	2.1908e+02
289	recruitment	1.9893e+03	1.7550e+02
290	recruitment	1.7526e+03	1.5540e+02
291	recruitment	1.5450e+03	1.4127e+02
292	recruitment	2.1554e+03	1.8837e+02
293	recruitment	5.4410e+04	9.2557e+02
294	recruitment	2.5771e+03	2.5569e+02
295	recruitment	2.9805e+03	2.8754e+02
296	recruitment	8.7484e+03	5.4045e+02
297	recruitment	1.8298e+04	9.4363e+02
298	recruitment	8.9233e+03	8.7210e+02
299	recruitment	2.0102e+04	1.3199e+03
300	recruitment	1.3935e+04	1.0057e+03
301	recruitment	5.1233e+03	3.8348e+02
302	recruitment	3.5537e+03	3.1177e+02
303	recruitment	9.4473e+03	1.0097e+03
304	recruitment	8.1546e+04	2.4053e+03
305	recruitment	9.2673e+03	9.6254e+02
306	recruitment	2.5174e+04	1.8575e+03
307	recruitment	7.5532e+04	7.0835e+03
308	recruitment	5.1991e+05	1.6788e+04
309	recruitment	1.9215e+04	3.2723e+03

310	recruitment	1.9009e+04	3.4646e+03
311	recruitment	2.1036e+04	4.0031e+03
312	recruitment	2.6004e+04	5.4313e+03
313	recruitment	2.9868e+04	6.7058e+03
314	recruitment	3.0033e+04	6.7617e+03
315	endbiom	1.5392e+05	2.0941e+03
316	depletion_popnbiom	5.1047e-01	1.5690e-02
317	endspawn	1.3267e+05	1.7057e+03
318	depspawn	4.7294e-01	1.5553e-02
319	deppopnbiom63	1.1171e+00	1.4645e-02
320	depspawn63	1.1720e+00	1.5310e-02
321	endN	3.0033e+04	6.7617e+03
322	endN	2.8411e+04	6.3787e+03
323	endN	2.3529e+04	4.9144e+03
324	endN	1.8105e+04	3.4453e+03
325	endN	1.5559e+04	2.8358e+03
326	endN	1.4947e+04	2.5455e+03
327	endN	3.8386e+05	1.2401e+04
328	endN	5.2877e+04	4.9593e+03
329	endN	1.6688e+04	1.2315e+03
330	endN	5.8013e+03	6.0261e+02
331	endN	4.8079e+04	1.4226e+03
332	endN	5.2266e+03	5.5882e+02
333	endN	1.8349e+03	1.6108e+02
334	endN	2.4639e+03	1.8462e+02
335	endN	6.2406e+03	4.5097e+02
336	endN	8.3395e+03	5.4927e+02
337	endN	3.4063e+03	3.3332e+02
338	endN	6.3448e+03	3.2869e+02
339	endN	2.6956e+03	1.6712e+02
340	endN	7.9452e+02	7.6755e+01
341	endN	5.7673e+02	5.7362e+01
342	endN	9.9533e+03	1.9368e+02
343	endN	3.1103e+02	2.7441e+01
344	endN	1.7020e+02	1.5716e+01
345	endN	1.4672e+02	1.3172e+01
346	endN	1.1422e+04	2.5474e+02
347	endF	2.8086e-03	7.7356e-05