A Review of Inputs and Outputs of Fisheries Tools

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1. Ecology and fisheries simulators

1.1 Atlantis

- Use Atlantis as an example. For more details on using Atlantis see this link.

- Atlantis model structure

  - Geometry submodel
    * Description of model box shapes
  - Physics submodel
    * Physical processes parameters
    * Initial concentrations and distributions of model variables
    * Hydrodynamic forcing of the transport model
    * Environmental drivers such as temperature, salinity, nutient inputs, river flows, and contaminants
  - Biology submodel
    * Initial concentrations and distributions of model variables
    * List of functional groups and their key biological characteristics
    * Biological interaction parameters
    * Biological drivers such as recruitment, extra mortality, and dispersal
  - Harvest submodel
    * List of fisheries and their key characteristics
    * Human impacts parameters
    * Catches and discards
  - Economics submodel
    * Socio-economic interaction parameters
    * prices

- The structure of input files (* means essential files)

```
##                     levelName                                        description
## 1   Inputs
## 2    ¦--catchts
## 3    ¦   ¦--boundary.ts          Blank catch file for use with boundary boxes
## 4    ¦   ¦--catch1.ts            Historical catch time series file for box 1
## 5    ¦   ¦--catch2.ts            Historical catch time series file for box 2
## 6    ¦   ¦--catch3.ts            Historical catch time series file for box 3
## 7    ¦   ¦--catch4.ts            Historical catch time series file for box 4
## 8    ¦   °--catch5.ts            Historical catch time series file for box 5
## 9    ¦--essential_optional_files
## 10   ¦   ¦--Biology.prm                    *Set up ecological parameters, etc
## 11   ¦   ¦--Fisheries.csv              *Fisheries name, recreation info, etc
## 12   ¦   ¦--Forcings.prm                   *Lays out the forcing file pathways
## 13   ¦   ¦--Functional_groups.csv   *Biological, fishing, and management info
## 14   ¦   ¦--Geography.bgm                              *Geometry of boxes
## 15   ¦   ¦--Harvest.prm                 Fisheries and management parameters
## 16   ¦   ¦--Initial_condition.cdf   Convert .nc toreadable and editable file
## 17   ¦   ¦--Initial_condition.nc        *Initial biomass and age structure
## 18   ¦   ¦--Physics.prm                               *Physics parameters
## 19   ¦   °--Run_settings.prm            *Time setp, run and stop time, etc
## 20   ¦--forcisets
## 21   ¦   ¦--pCO2RCP85.ts                         pCO2 data time series
## 22   ¦   ¦--SETAS_pH.nc                      pH data for physics submodel
## 23   ¦   ¦--SETAS_VMPAArsenic.nc    Contaminants tracer of functional groups
## 24   ¦   ¦--SETAS_VMPAhydroA.nc            *Hyrodynamics forcing input file
## 25   ¦   ¦--SETAS_VMPAhydroB.nc            *Hyrodynamics forcing input file
## 26   ¦   ¦--SETAS_VMPAhydroC.nc            *Hyrodynamics forcing input file
## 27   ¦   ¦--SETAS_VMPAhydroD.nc            *Hyrodynamics forcing input file
## 28   ¦   ¦--SETAS_VMPAhydroE.nc            *Hyrodynamics forcing input file
## 29   ¦   ¦--SETAS_VMPAoxygen.cdf   Convert .nc to readable and editable file
## 30   ¦   ¦--SETAS_VMPAoxygen.nc                              Oxygen data
## 31   ¦   ¦--SETAS_VMPAsalt.nc                             Salinity data
## 32   ¦   ¦--SETAS_VMPAtemp.cdf     Convert .nc to readable and editable file
## 33   ¦   ¦--SETAS_VMPAtemp.nc                          Temperature data
## 34   ¦   °--solar9195.ts                          Solar radiation data
## 35   °--meteor
## 36       ¦--84-95.nc                                  Evaporation data
## 37       °--times1.6.nc                             Precipitation data
```

- The structure of output files

```
##                            levelName                                    description
## 1   Outputs
## 2   ¦--Biology.xml                          Readable converted input file
## 3   ¦--BiomIndx.txt                        Biomass in tonnes of each species
## 4   ¦--delete_to_halt_run                           Write outputs to date
## 5   ¦--export.ts                                        Net mass changes
## 6   ¦--Fisheries.xml                        Readable converted input file
## 7   ¦--Functional_groups.xml                Readable converted input file
## 8   ¦--Geography.bgm                                   Box model geometry
## 9   ¦--Harvest.xml                          Readable converted input file
## 10  ¦--implementation.xml                   Readable converted input file
## 11  ¦--inputs.ts                               Total tracer inputs
## 12  ¦--log.txt                          Messages generated during the run
## 13  ¦--outputs.nc                       3D snapshots of the tracer values
## 14  ¦--outputs_BrokenStick.txt       Broken stick harvest strategy indices
## 15  ¦--outputs_management.xml               Readable converted input file
## 16  ¦--outputsAgeBiomIndx.txt          Biomass of all species per age group
## 17  ¦--outputsAnnualAgeBiomIndx.txt        Annual biomass index per age
## 18  ¦--outputsBiomIndx.txt                 Biomasses of all active species
## 19  ¦--outputsBiomReg.txt                   Similar to BiomIndx outputs?
## 20  ¦--outputsBoxBiomass.txt             Biomass of all species per box
## 21  ¦--outputsCATCH.nc                    Landing per species per fishery
## 22  ¦--outputsCatch.txt               Landing per species over all fisheries
## 23  ¦--outputsCatchPerFishery.txt        Landing per species per fishery
## 24  ¦--outputsDietCheck.txt                 Indication of diet pressure
## 25  ¦--outputsDiscard.txt            Discards per species over all fisheries
## 26  ¦--outputsDiscardPerFishery.txt      Discards per species per fishery
## 27  ¦--outputsEffort.txt             Number of days per fishery for fishing
## 28  ¦--outputsHarvestIndx.txt           Fisheries and management indices
## 29  ¦--outputsMigration.txt         Migrating biomass per adults & juveniles
## 30  ¦--outputsMort.txt              Natural and fishing mortality per species
## 31  ¦--outputsMortPerPred.txt        Mortality of species by each predator?
## 32  ¦--outputsPredPropCheck.txt                 Indication of predation?
## 33  ¦--outputsPROD.nc                   2D snapshorts of diagnostic tracers
## 34  ¦--outputsRecCatch.txt                 Recreational catch per species
## 35  ¦--outputsSpecificMort.txt         3 values of instantaneous mortality
## 36  ¦--outputsSpecificPredMort.txt    Mortality of species by each predator
## 37  ¦--outputsSSB.txt                     Mature biomass at spawning time
## 38  ¦--outputsTAC.txt                            TAC per species per year
## 39  ¦--outputsTOT.nc                    2D snapshorts of tracers per box
## 40  ¦--outputsTOTCATCH.nc              Total catch per species in tonnes
## 41  ¦--outputsVertSize.txt           Sizes of migrating age structured group
## 42  ¦--outputsYOY.txt                  Biomass of recruits at spawning time
## 43  °--Run_settings.xml                     Readable converted input file
```

2. Stock assessment operating tools

2.1 Atlantisom

- Use Atlantisom as an example. For more details on using Atlantisom see this link.

- Atlantisom model structure

  - Import simulated truth form Atlantis
    * Get biomass, abundance, age composition, length composition, weight-at-age for each species
    * Get fishery catch, catch-at-age, fishery length composition, and fishery weight-at-age for each species
  - Specify uncertainty in observed data
    * Survey specifications (e.g., timing and spatial coverage) and uncertainty (e.g., observation error and effective sample size)
    * Fishery specifications (e.g., sampling areas) and uncertainty (e.g., observation error and effective sample size)

  - Get other life history parameters from Atlantis Biology.prm file
    * Use weight-length relationship parameters from Atlantis to calculate h, R0
    * Use natural mortality from Atlantis
    * Use survey length-at-age from Atlantis to estimate growth curve
  - Format data to run stock assessment models

- The structure of input files (use ANNAGEBIO.nc and ANNAGECATCH.nc if available)

```
##                      levelName                              description
## 1   Inputs
## 2   ¦--Biology.prm                      Set up ecological parameters, etc
## 3   ¦--BiomIndx.txt                     Biomass in tonnes of each species
## 4   ¦--Fisheries.csv              Fisheries name, recreation info, etc
## 5   ¦--Functional_groups.csv    Biological, fishing, and management info
## 6   ¦--Geography.bgm                              Geometry of boxes
## 7   ¦--Initial_condition.nc          Initial biomass and age structure
## 8   ¦--outputs.nc                      3D snapshots of the tracer values
## 9   ¦--outputsCATCH.nc               Landing per species per fishery
## 10  ¦--outputsCatch.txt          Landing per species over all fisheries
## 11  ¦--outputsCatchPerFishery.txt       Landing per species per fishery
## 12  ¦--outputsDietCheck.txt               Indication of diet pressure
## 13  ¦--outputsPROD.nc             2D snapshorts of diagnostic tracers
## 14  ¦--outputsYOY.txt            Biomass of recruits at spawning time
## 15  °--Run_settings.xml             Time setp, run and stop time, etc
```

- The structure of output files

```
##                            levelName                            description
## 1 Outputs
## 2  ¦--outputscatchage_census.rds        Catch at age per species per time
## 3  ¦--outputscatchlengthwt_census.rds    Len and wt at age, num at length
## 4  ¦--outputscatchN_census.rds          Catch number per species per time
## 5  ¦--outputslengthwt_census.rds         Len and wt at age, num at length
## 6  ¦--outputsnatage_census.rds       Survey num at age per species per time
## 7  ¦--outputsrun_truth.RData           Atlantis true outputs (biomass etc)
## 8  ¦--outputssurveyBcensus.rds         Survey biomass per species per time
## 9  °--outputssurveyNcensus.rds        Survey abundance per species per time
```

3. Stock assessment tools

3.1 Stock Synthesis (SS)

- Use SS as an single-species assessment example. For more details on using SS see this link.

- SS structure

3.2 Globally applicable Area Disaggregated General Ecosystem Toolbox (Gadget)

- Use Gadget as an multi-species assessment example. For more details on using Gadget see these links:
    - gadget2
    - rgadget
    - gadget courses
- Gadget structure
    - Specify model years, time steps, areas, temperature of areas
    - Provide information of stocks
        * Biological information such as minage and minlength
        * Key components such as growth model, natural mortality for each age group, predator-prey determination, initial condition, migration, maturity, movement, renew, spawn, and stray information
        * Predation is modelled in terms of size and it includes consumption and cannibalistic relationships
        * Recruitment can be modeled as result of spawning and independent renewal
    - Add human interactions as removals of stock
        * Provide fleet type,selectivity, and catch data
- The structure of input files

```
##                         levelName                            description
## 1   Inputs
## 2    ¦--Aggfiles
## 3    ¦    ¦--lingimm.stock.len.agg              Bounds of length class
## 4    ¦    °--lingmat.stock.len.agg              Bounds of length class
## 5    ¦--Data
## 6    ¦    ¦--fleet.bmt.data               Catch weight per time per area
## 7    ¦    ¦--fleet.foreign.data           Catch weight per time per area
## 8    ¦    ¦--fleet.gil.data               Catch weight per time per area
## 9    ¦    ¦--fleet.lln.data               Catch weight per time per area
## 10   ¦    °--fleet.surv.data              Survey number per time per area
## 11   ¦--lingimm                          Biological information of stock
## 12   ¦--lingmat                          Biological information of stock
## 13   ¦--main                                                 File paths
## 14   ¦--Modelfiles
## 15   ¦    ¦--area                    Area and temperature per time step
## 16   ¦    ¦--fleet                   Fleet selectivity information etc
## 17   ¦    ¦--lingimm.init.normalparam       Initial condition equations
## 18   ¦    ¦--lingimm.maturity               Maturity parameter values
## 19   ¦    ¦--lingimm.refwgt                    Weight at length class
## 20   ¦    ¦--lingmat.init.normalparam       Initial condition equations
## 21   ¦    ¦--lingmat.refwgt                    Weight at length class
## 22   ¦    °--time                   Year, time step and its duration
## 23   °--params.forsim               Parameter values for simulation
```

- The structure of output files

```
##                        levelName                           description
## 1  Outputs
## 2    ¦--FIT
## 3    ¦   ¦--main.print                                      File paths
## 4    ¦   ¦--out.fit
## 5    ¦   ¦   ¦--lingimm.full          Num and wt of stock by length class
## 6    ¦   ¦   ¦--lingimm.prey               Num and wt caught by all fleets
## 7    ¦   ¦   ¦--lingimm.prey.bmt            Num and wt caught by one fleet
## 8    ¦   ¦   ¦--lingimm.prey.foreign        Num and wt caught by one fleet
## 9    ¦   ¦   ¦--lingimm.prey.gil            Num and wt caught by one fleet
## 10   ¦   ¦   ¦--lingimm.prey.lln            Num and wt caught by one fleet
## 11   ¦   ¦   ¦--lingimm.prey.surv           Num and wt caught by one fleet
## 12   ¦   ¦   ¦--lingimm.recruitment  Num and wt of recruits by length and step
## 13   ¦   ¦   ¦--lingimm.std          Biological info by age, step, and area
## 14   ¦   ¦   ¦--lingmat.full          Num and wt of stock by length class
## 15   ¦   ¦   ¦--lingmat.prey               Num and wt caught by all fleets
## 16   ¦   ¦   ¦--lingmat.prey.bmt            Num and wt caught by one fleet
## 17   ¦   ¦   ¦--lingmat.prey.foreign        Num and wt caught by one fleet
## 18   ¦   ¦   ¦--lingmat.prey.gil            Num and wt caught by one fleet
## 19   ¦   ¦   ¦--lingmat.prey.lln            Num and wt caught by one fleet
## 20   ¦   ¦   ¦--lingmat.prey.surv           Num and wt caught by one fleet
## 21   ¦   ¦   ¦--lingmat.recruitment  Num and wt of recruits by length and step
## 22   ¦   ¦   °--lingmat.std          Biological info by age, step, and area
## 23   ¦   ¦--print.aggfiles
## 24   ¦   ¦   ¦--lingimm.age.agg                            Min to max age
## 25   ¦   ¦   ¦--lingimm.allages.agg                        Min to max age
## 26   ¦   ¦   ¦--lingimm.alllen.agg              Min and max length classes
## 27   ¦   ¦   ¦--lingimm.area.agg                                     Area
## 28   ¦   ¦   ¦--lingimm.len.agg                    Bounds of length classes
## 29   ¦   ¦   ¦--lingimm.rec.age.agg                       Recruitment age
## 30   ¦   ¦   ¦--lingmat.age.agg                            Min to max age
## 31   ¦   ¦   ¦--lingmat.allages.agg                        Min to max age
## 32   ¦   ¦   ¦--lingmat.alllen.agg              Min and max length classes
## 33   ¦   ¦   ¦--lingmat.area.agg                                     Area
## 34   ¦   ¦   ¦--lingmat.len.agg                    Bounds of length classes
## 35   ¦   ¦   °--lingmat.rec.age.agg                       Recruitment age
## 36   ¦   ¦--printfile.fit                                     File paths
## 37   ¦   ¦--SS.print                      List of parameters used in the run
## 38   ¦   °--WGTS.Rdata                           Outputs in Rdata format
## 39   ¦--ling_log                                     Log of model run
## 40   °--params.out                      Estimation values of parameters
```

7

4. Forecasting tools

- Required inputs and forecasting outputs of potential tools

  – Gadget projections
    * Need to set up stock biological parameterizations
    * Need to keep original parameter settings or: adding a recruitment series; modifying reference points used to control fishin behavior, modifying harvest levels and errors
    * Can produce projections of immature and mature portinos of stocks and projections of each species in multispecies model
    * Can project fleet and its response to a harvest control rule/modifications of fishing behavior (e.g., inputs or outputs regulation, split effort/quota among fleets)
    * Can produce yield and spawning stock biomass over F
    * Can produce biomass, abundance, and catch over years under different harvest rates

- Capabilities of incorporating climate, ecosystem, and economic considerations

- Scenarios to explore and comparison criteria

5. Diagnostic tools