NOAA FISHERIES

NEFSC

Operating Model Description Multispecies Production Model (Kraken)

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Ecosystem Based Fishery Management Strategy Review
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TOR 7: Structure and Application of Operating Models

Model Structure

$$B_{i,t+1} = B_{i,t} + r_i B_{i,t} - B_{i,t} \sum_{1}^{j} \alpha_{ij} B_{j,t} - C_i$$

$B =$ biomass $\quad r =$ growth rate $\quad C =$ catch

$\alpha_{i,i} =$ density dependent term

$\alpha_{i,j} =$ interaction coefficient

$$B_{i,t} = I_{i,t} q_i$$

$I_i =$ index for species i

$q_i =$ survey catchability on species i

Additional Features

Multiple functional forms for:

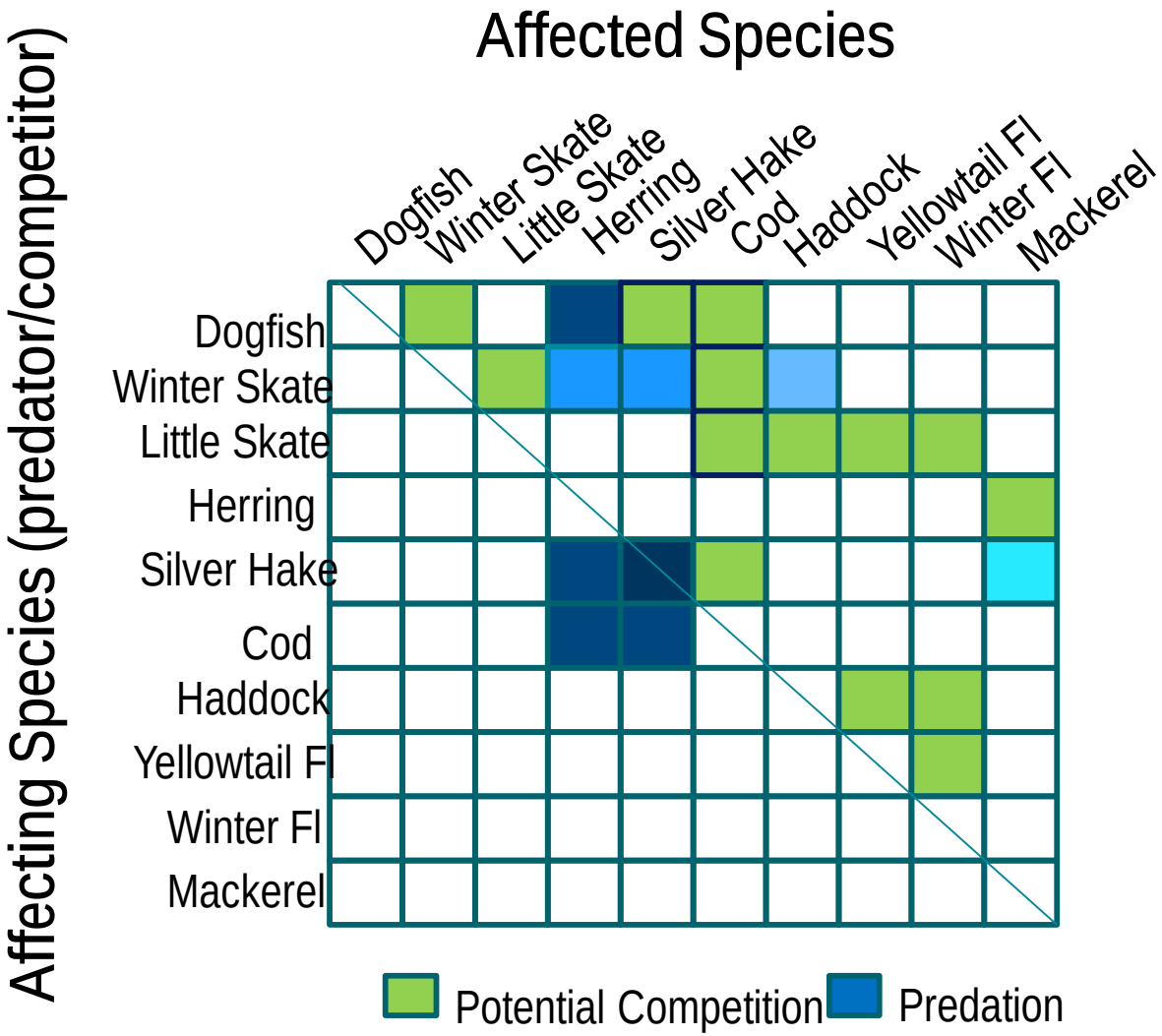
- Growth: Linear, logistic
- Predation: Type I, Type II, Type III
- Harvest: Catch TS, effort/catchability, exploitation rate

Genetic algorithm for estimation

Covariates on growth or carrying capacity

New GUI interface in the works

Interactions Between Species



Data Needs

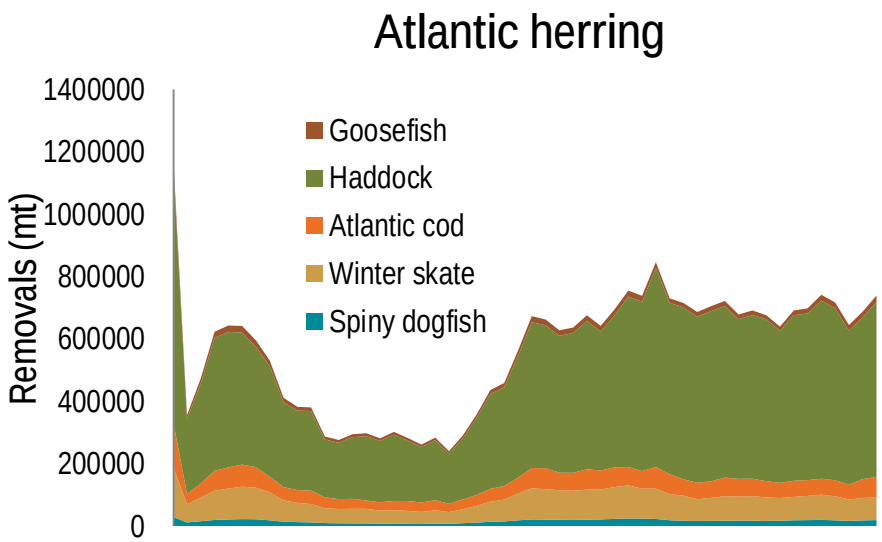
Mandatory:

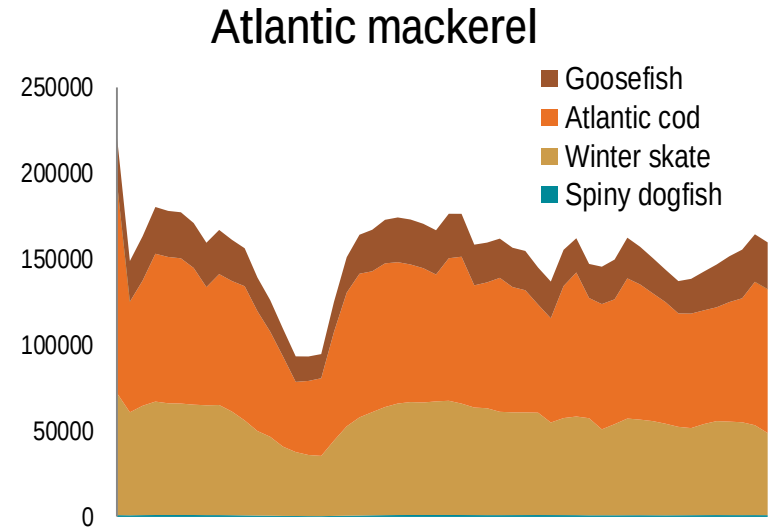
- Biomass/abundance time series or survey index
- Catch time series

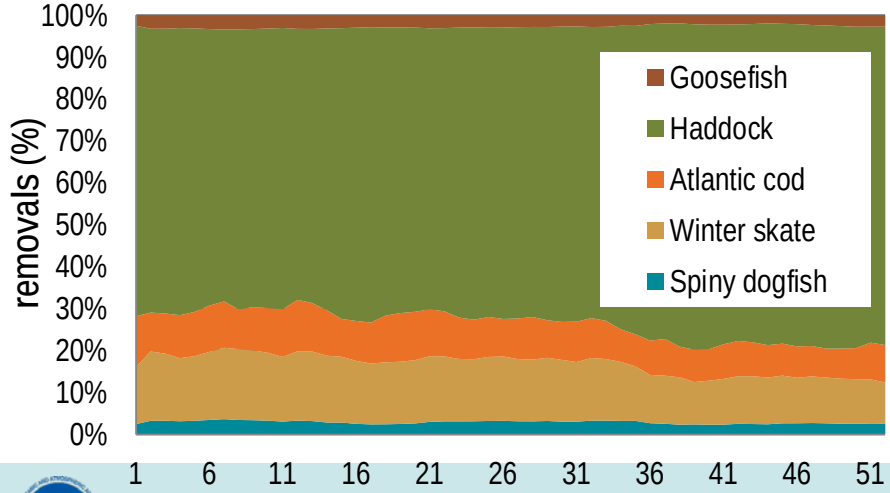
Optional:

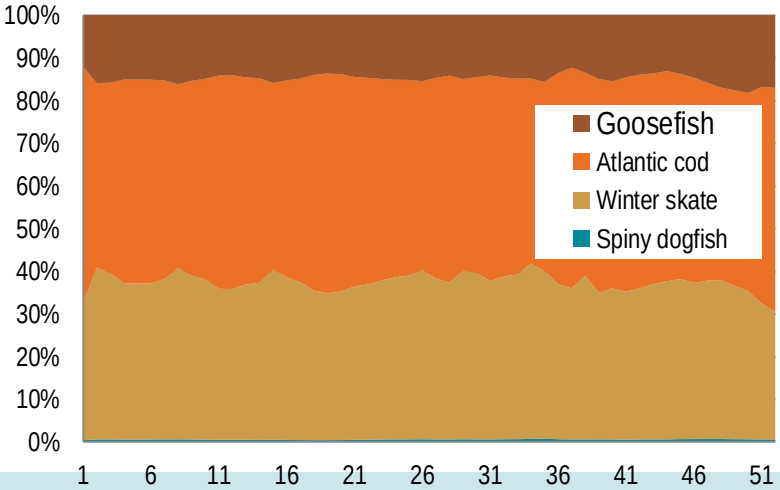
- Environmental covariates on growth or carrying capacity
- Food habits by percentage of prey in predator's diet (informs interaction coefficients)

Sample Results: Removals









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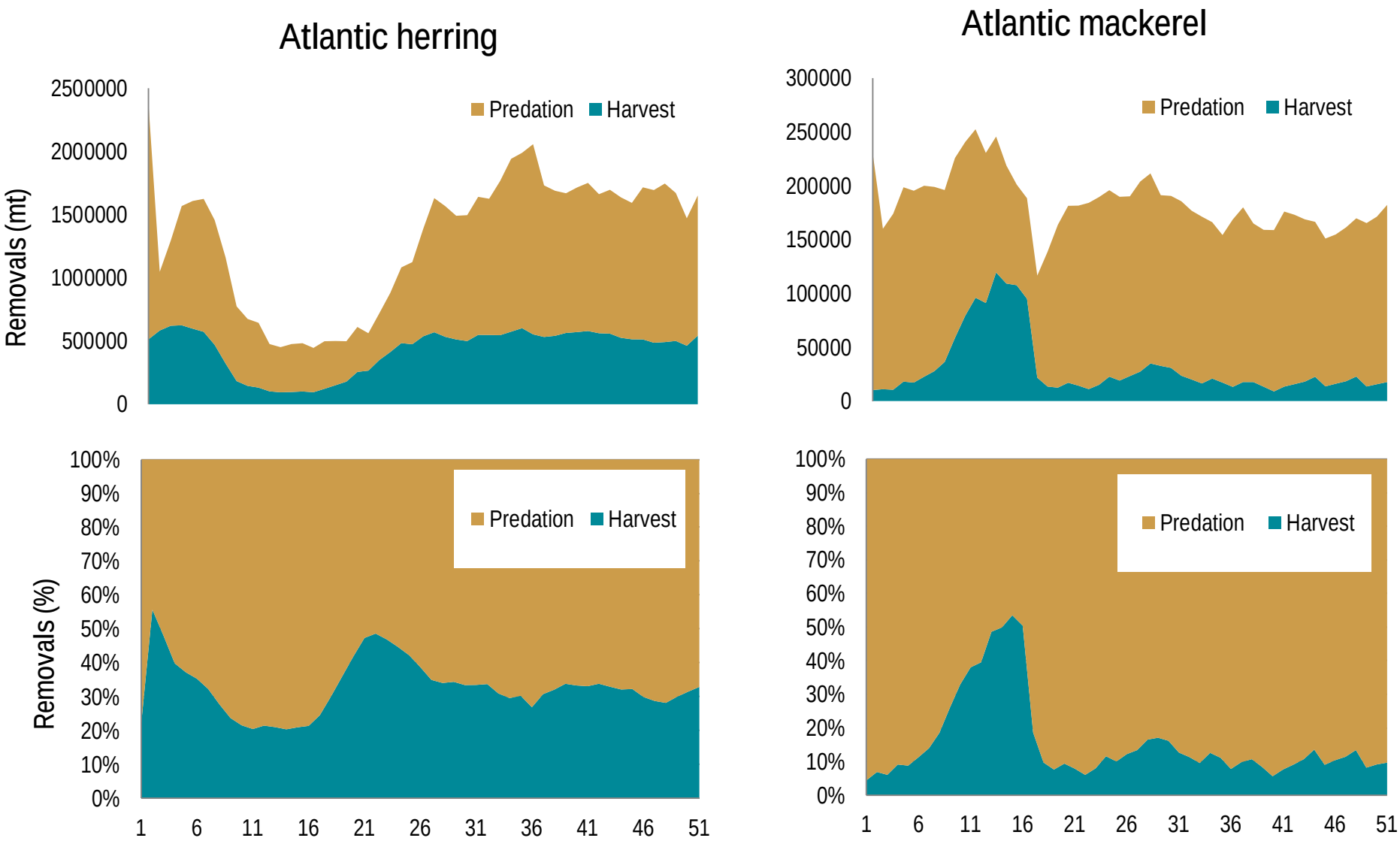
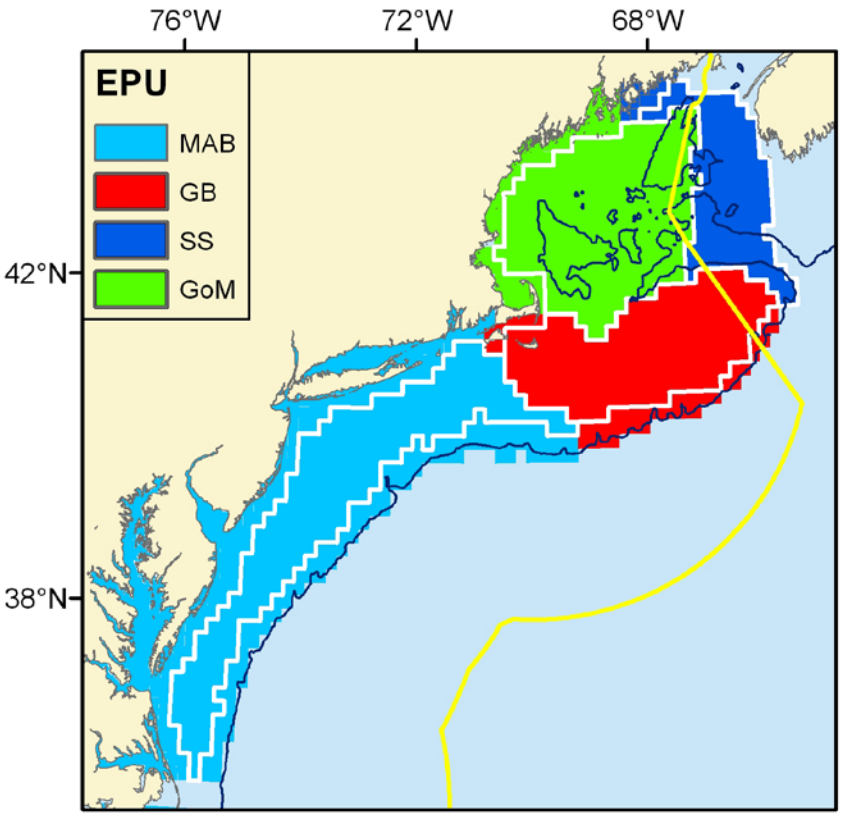


Species in Operating Model

Georges Bank EPU

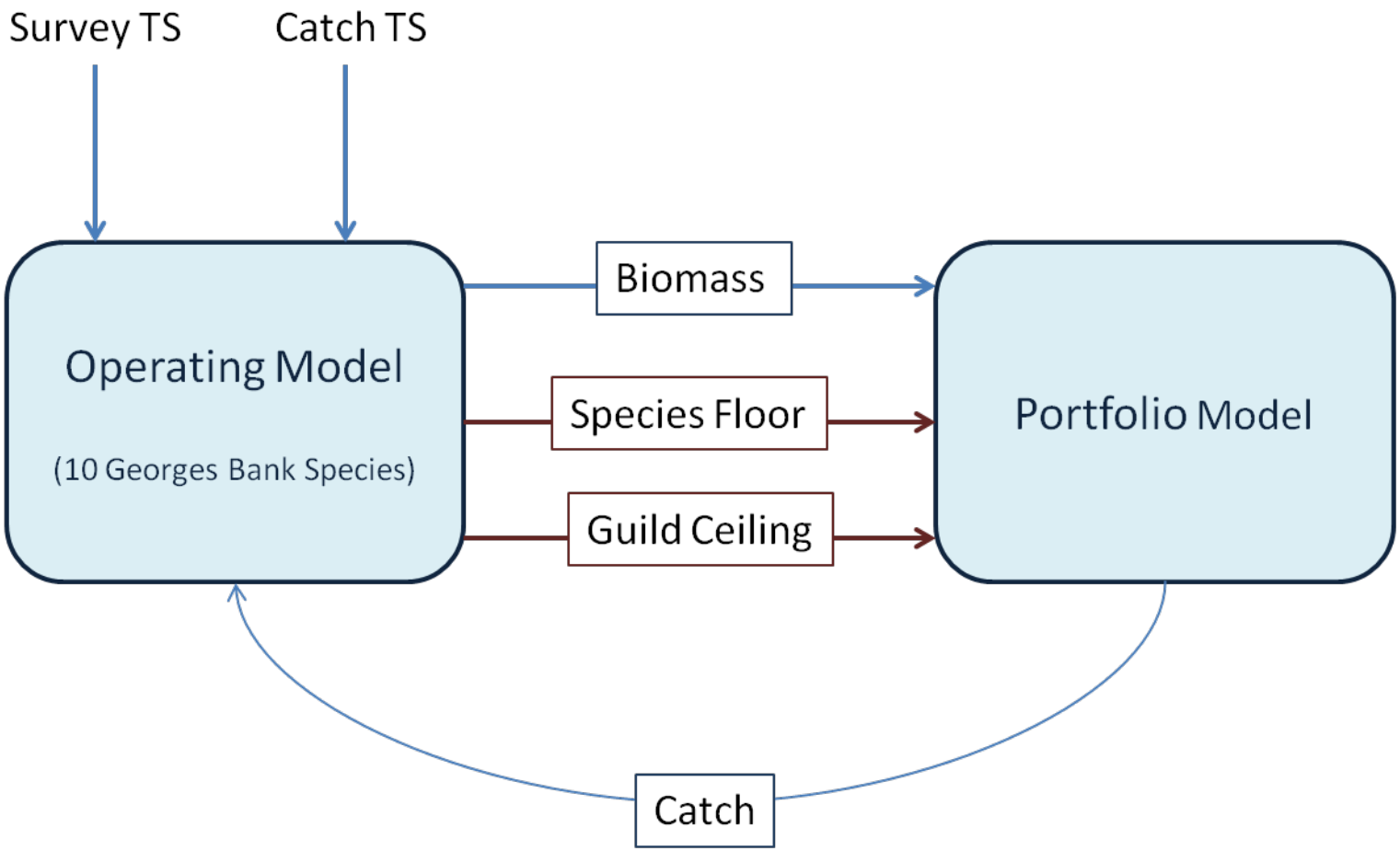


Atlantic cod
Goosefish
Spiny dogfish
Skates (Little and Winter)
Silver hake
Haddock
Yellowtail flounder
Winter flounder
Atlantic herring
Mackerel

Guilds

Piscivore
Benthivore
Mesoplanktivore

Diagram of work flow in coupled models



Next Steps

More robust estimation routines

More realistic fleet structure

Simulations to compare current management strategies with portfolio model

Simulations with misspecified reference points

Questions?

Genetic Algorithm: Overview

Features:

- Population based – can process a whole collection of candidate solutions simultaneously
- Recombination – mix information from two candidate solutions to create a new one
- Stochastic

Advantages:

- Relatively insensitive to initial values
- Will almost always find a ‘good’ solution
- Can escape local minima (and therefore can find the global minima)

Disadvantages:

- Potentially slower than other methods
- Not guaranteed to find the ‘best’ solution
- Not as familiar in fisheries science as maximum likelihood, least sum of squares, and other estimation methods

Genetic Algorithm: General Flow

1. Generate initial population of models
2. Test fitness of each model (based on RMSE)
3. Generate next generation of models through recombination and mutation
4. Repeat 2 and 3 for set number of generations or until a model has achieved a given fitness level

Recombination

Parent Model 1	$r = 0.400$	$a_{ii} = 0.0050$	$a_{ij} = 0.06$	$q_i = 0.80$
Parent Model 2	$r = 0.250$	$a_{ii} = 0.0100$	$a_{ij} = 0.90$	$q_i = 0.90$
Child Model	$r = 0.325$	$a_{ii} = 0.0525$	$a_{ij} = 0.48$	$q_i = 0.85$

Mutation

Child Model	$r = 0.325$	$a_{ii} = 0.0525$	$a_{ij} = 0.01$	$q_i = 0.85$