An Acoustic Survey Data Analysis framework for fish population data

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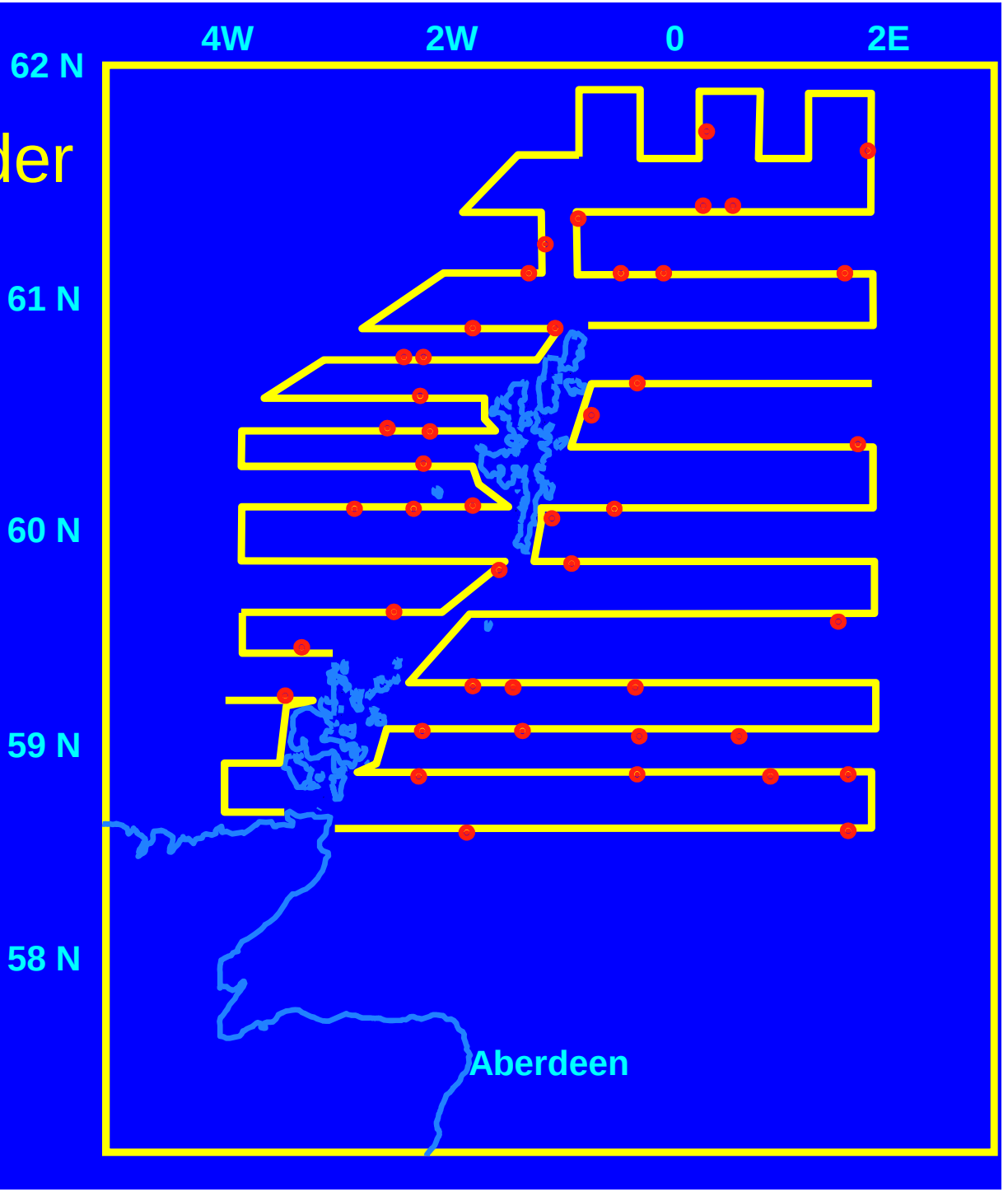
Survey Track
Vertical Echosounder Data

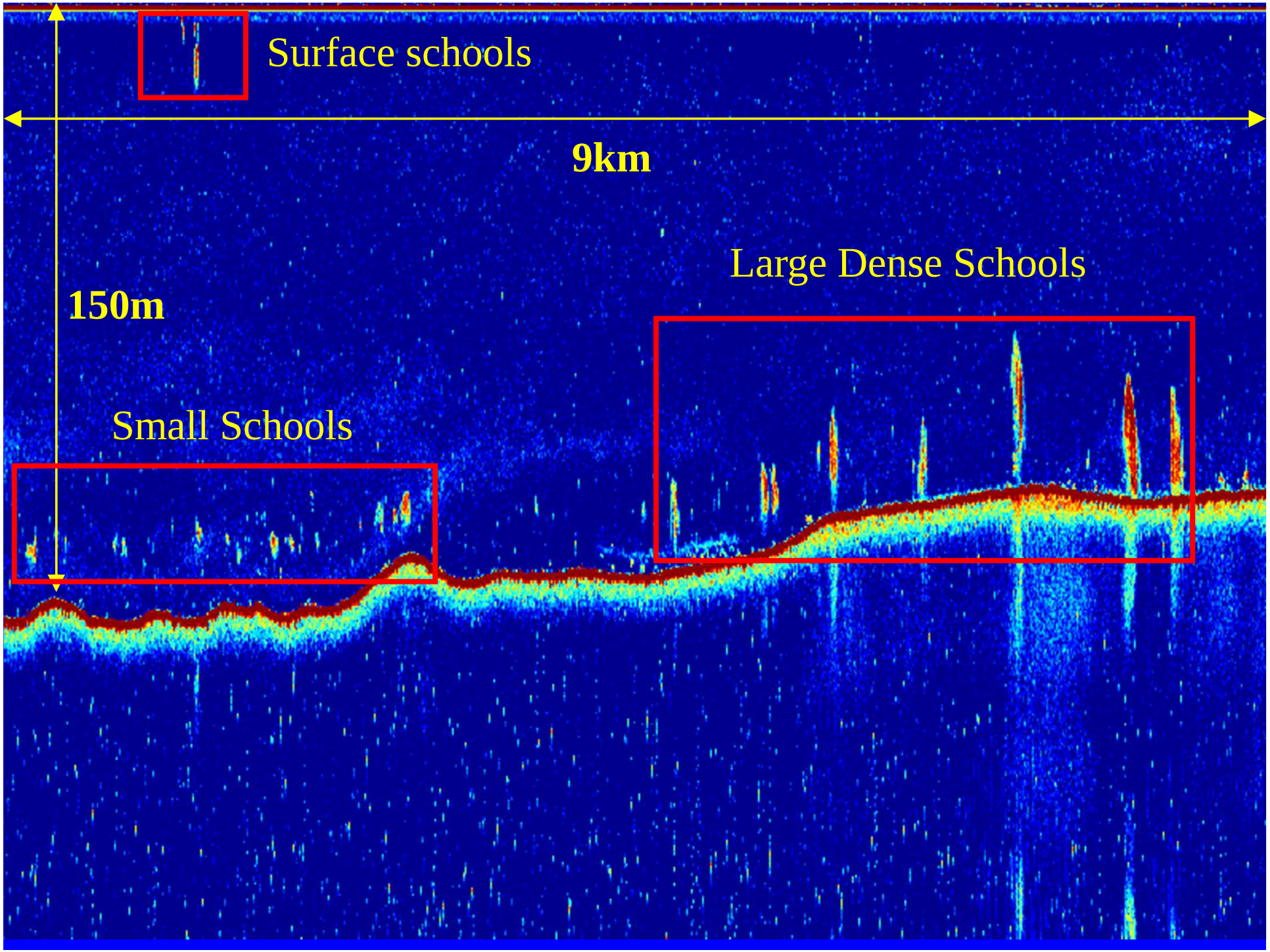
To provide:
Abundance or Biomass at age

Trawl Hauls
Identification,
Biological Data
Age, maturity
stock



Echo-sounde Data

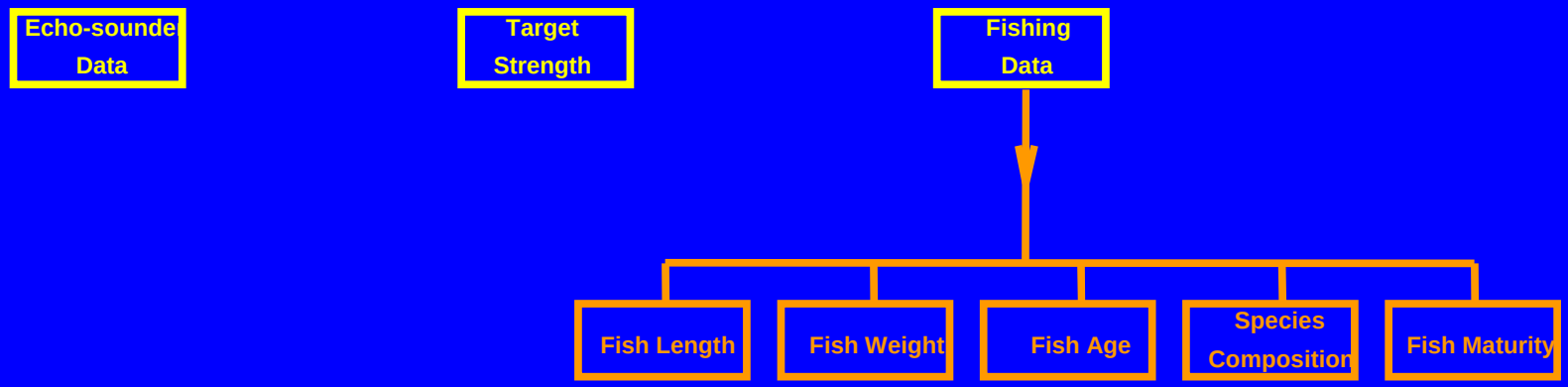
Echo View / BI O/P
Classified S_A


Surface schools
9km
150m
Large Dense Schools
Small Schools

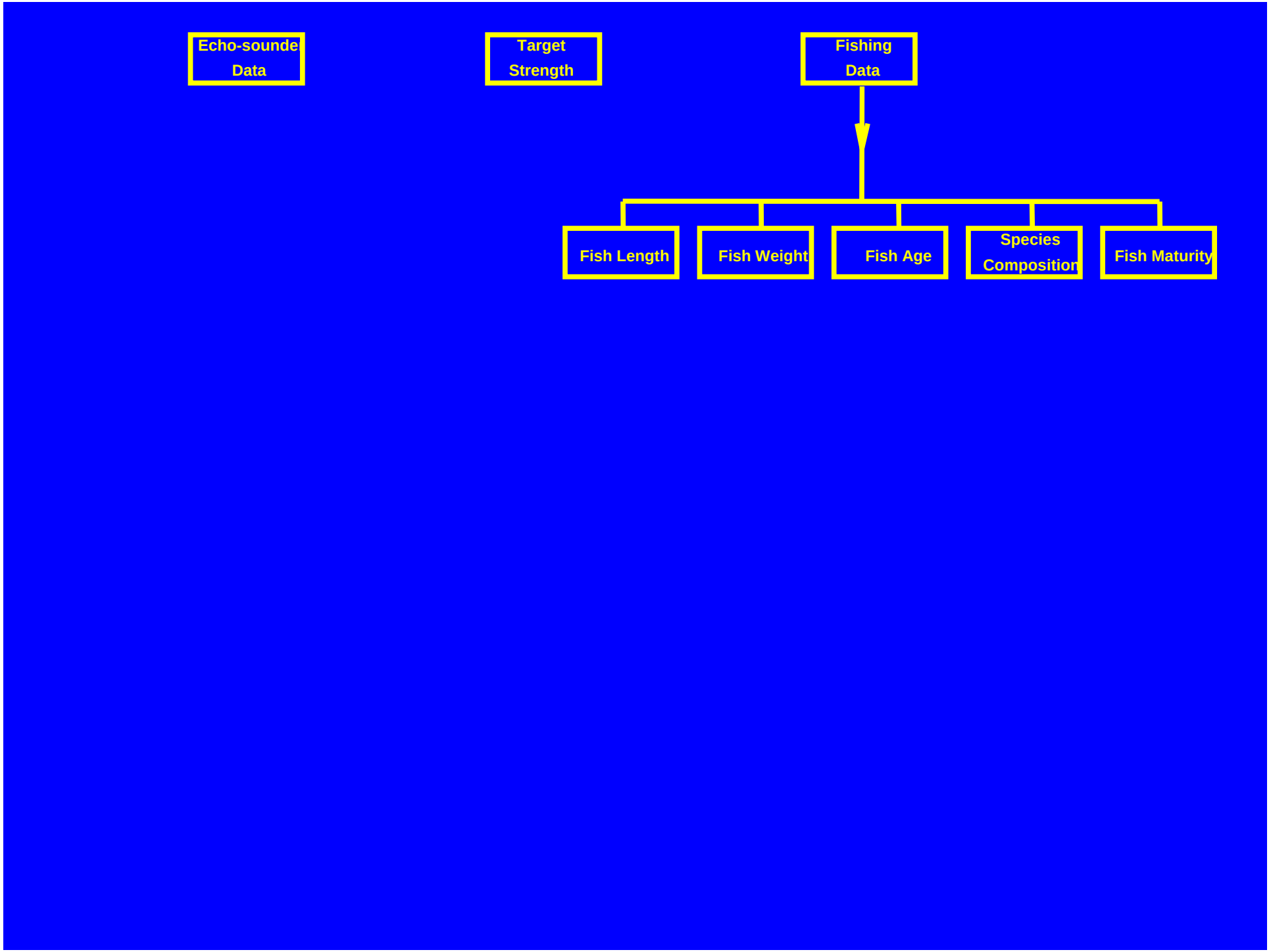
Echo-sounde Data

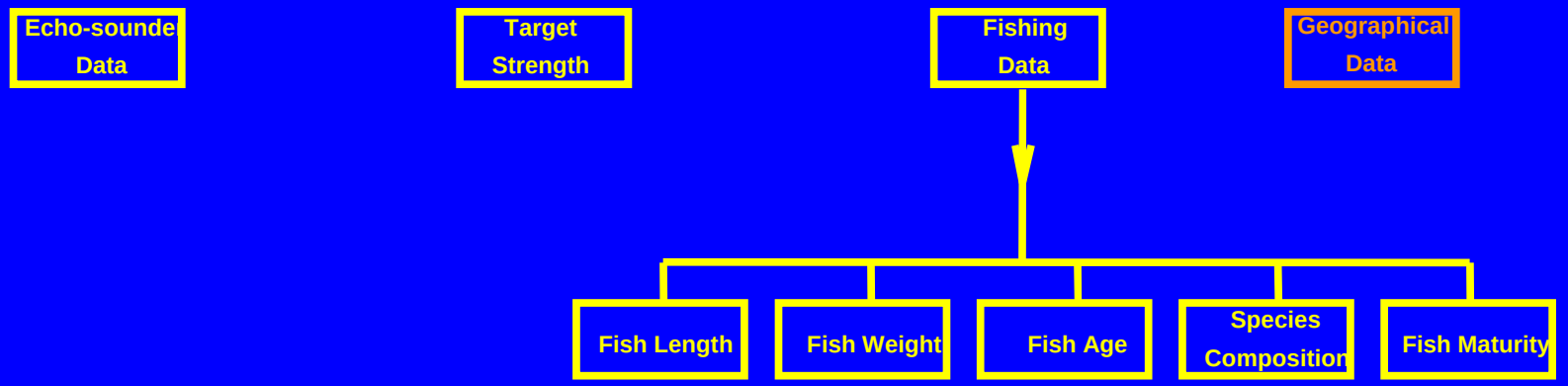
Target Strength

Target strength length distributions
Target strength relationships
Target strength observations
Target strength models



Geolographical referenced biological data by haul
Length Distributions
Weight at length data
Weight length relationships
Age Composition or
stratified age samples
Catch proportions
Biological data eg. maturity


Echo-sounde Data
Target Strength
Fishing Data
Fish Length
Fish Weight
Fish Age
Species Composition
Fish Maturity

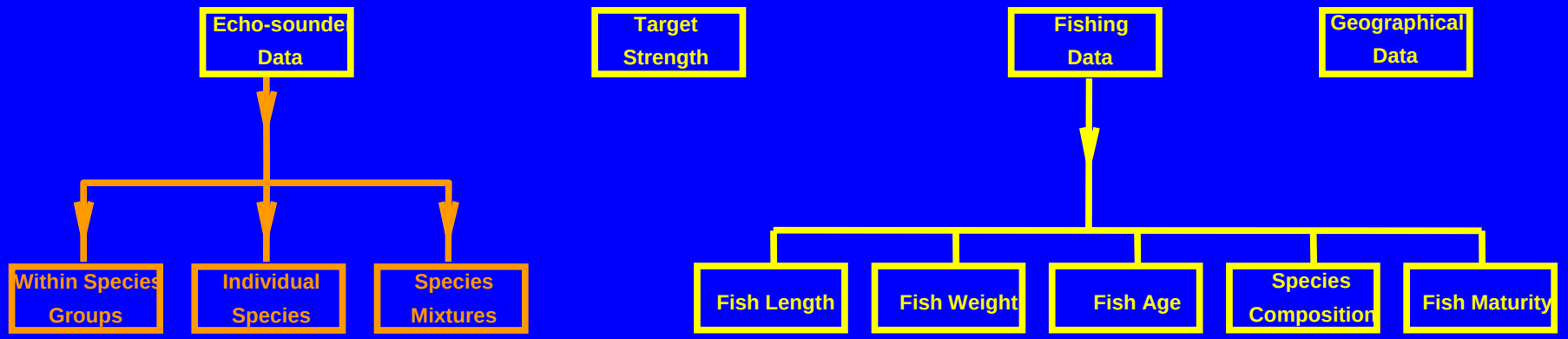


Defined limits of region for analysis

Choosing a grid definition for analysis

Allocation of valid areas / grid nodes for abundance

eg sea / land,


Echo-sounde Data
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Geographical Data
Within Species Groups
Individual Species
Species Mixtures
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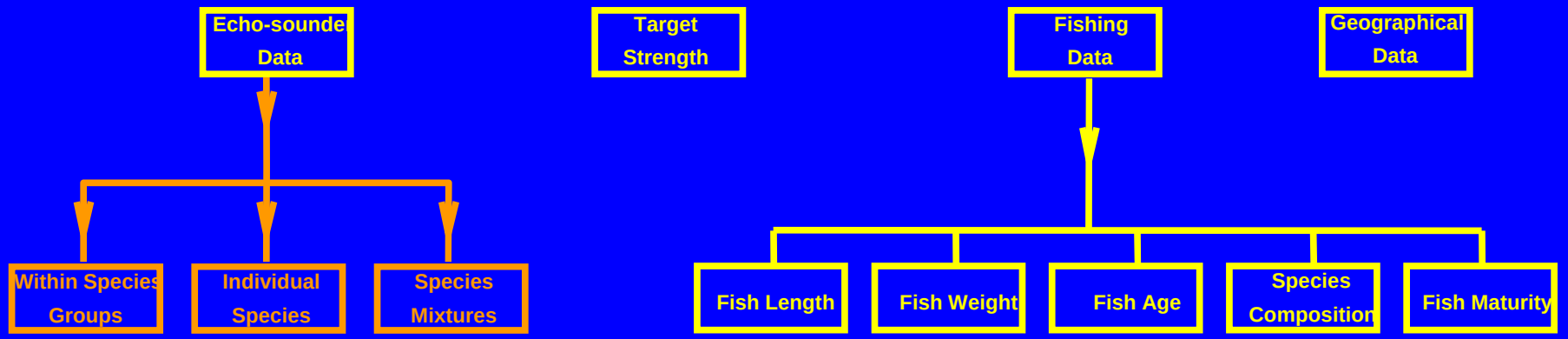
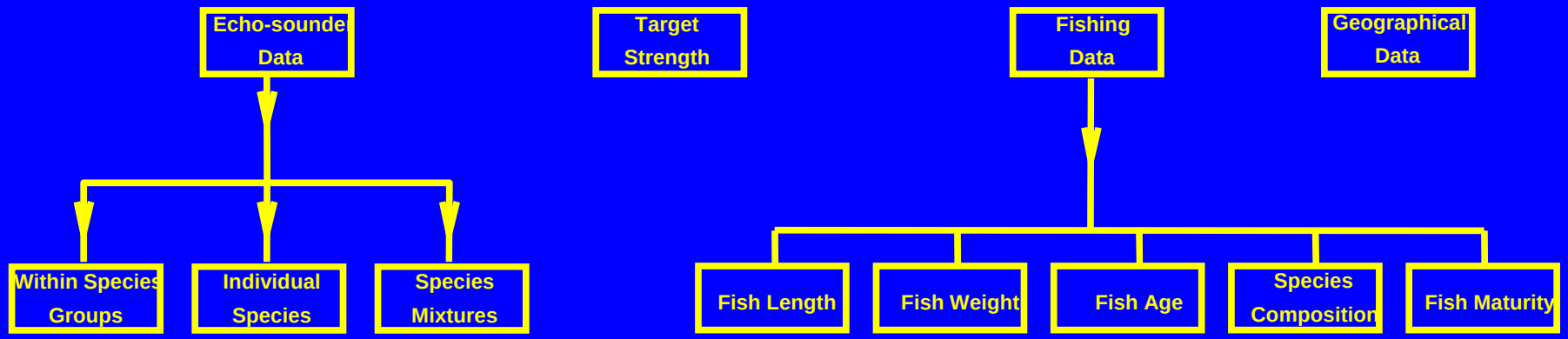


Depth stratified, size separated sub groups

Directly identified traces for a single species

Mixtures of species in a single category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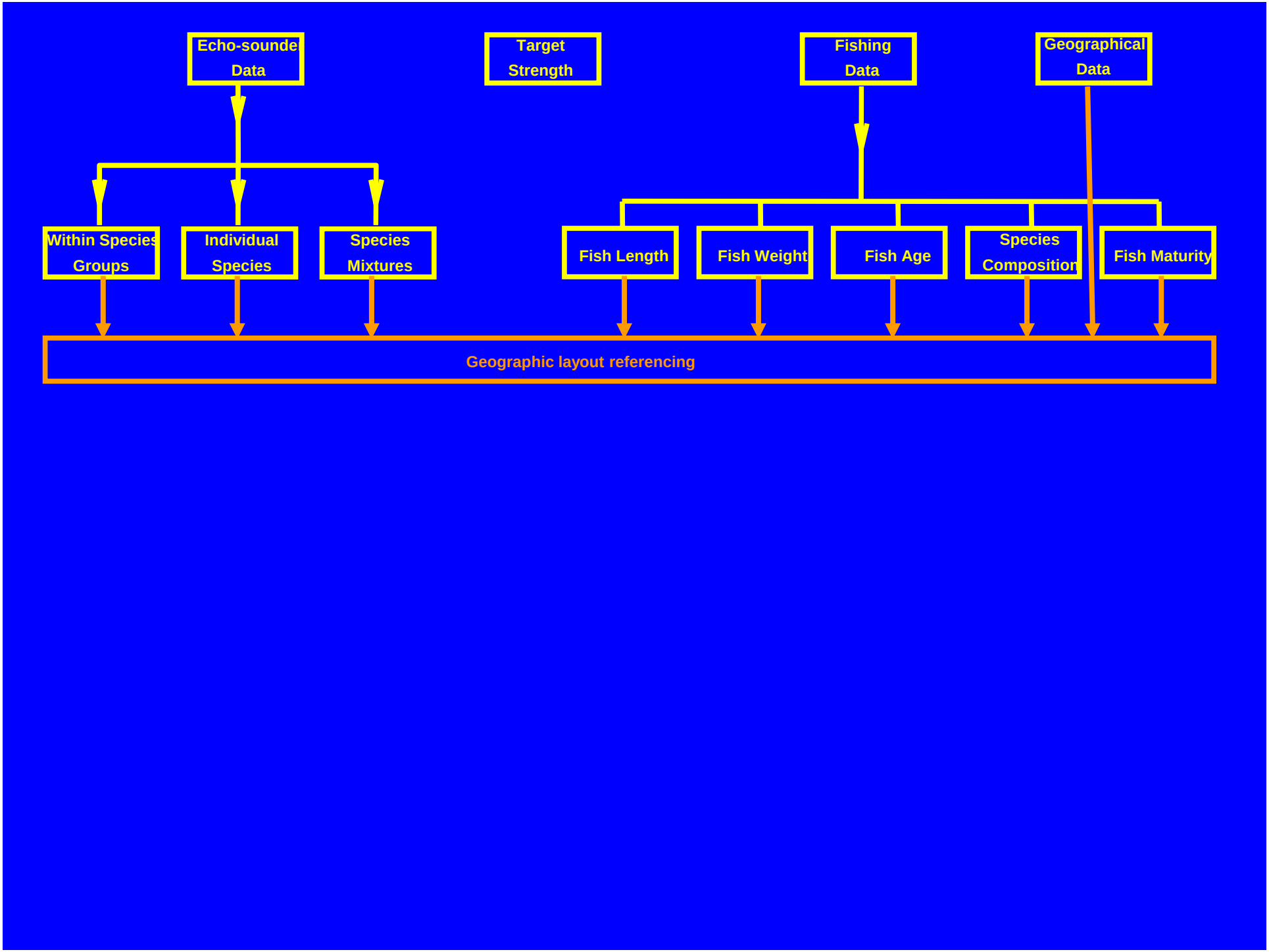
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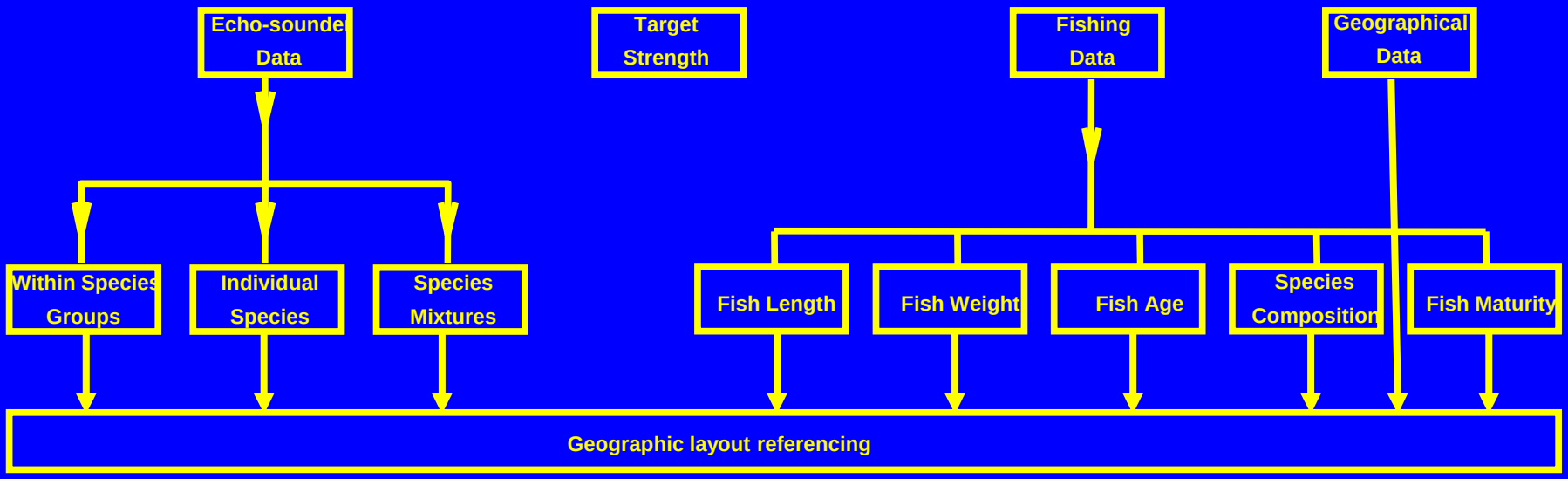
Geographic layout referencing

Geographic Referencing Averaging

- Weighted sum of parameter values
  - Selection of valid data
- Weighting methods
  - Nearest Neighbour
  - Area / region average
    - Equal weight
    - Weighted by catch rate
    - Weighted by integrator values
  - Kriged estimate
- Externally derived weighing file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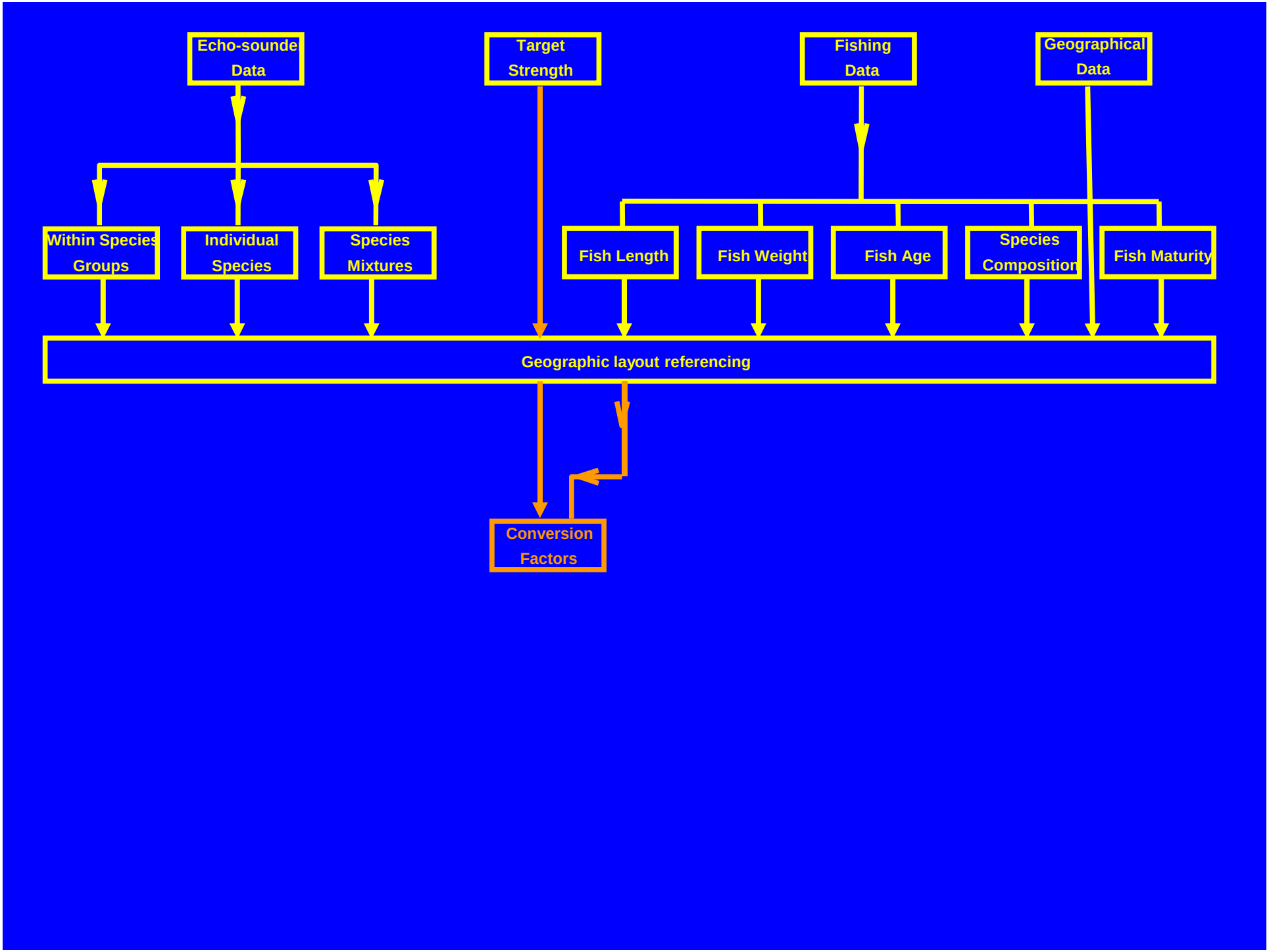
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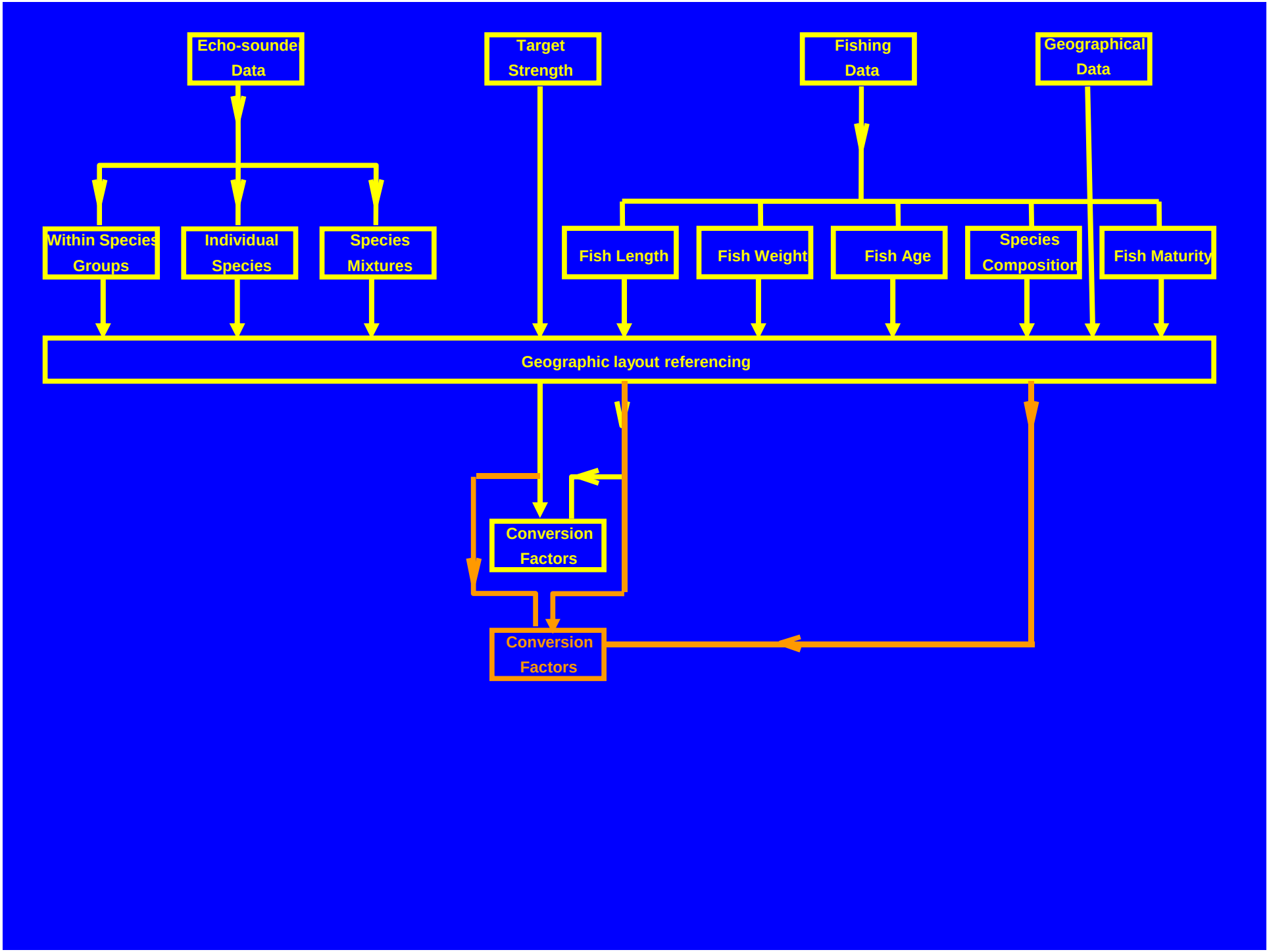
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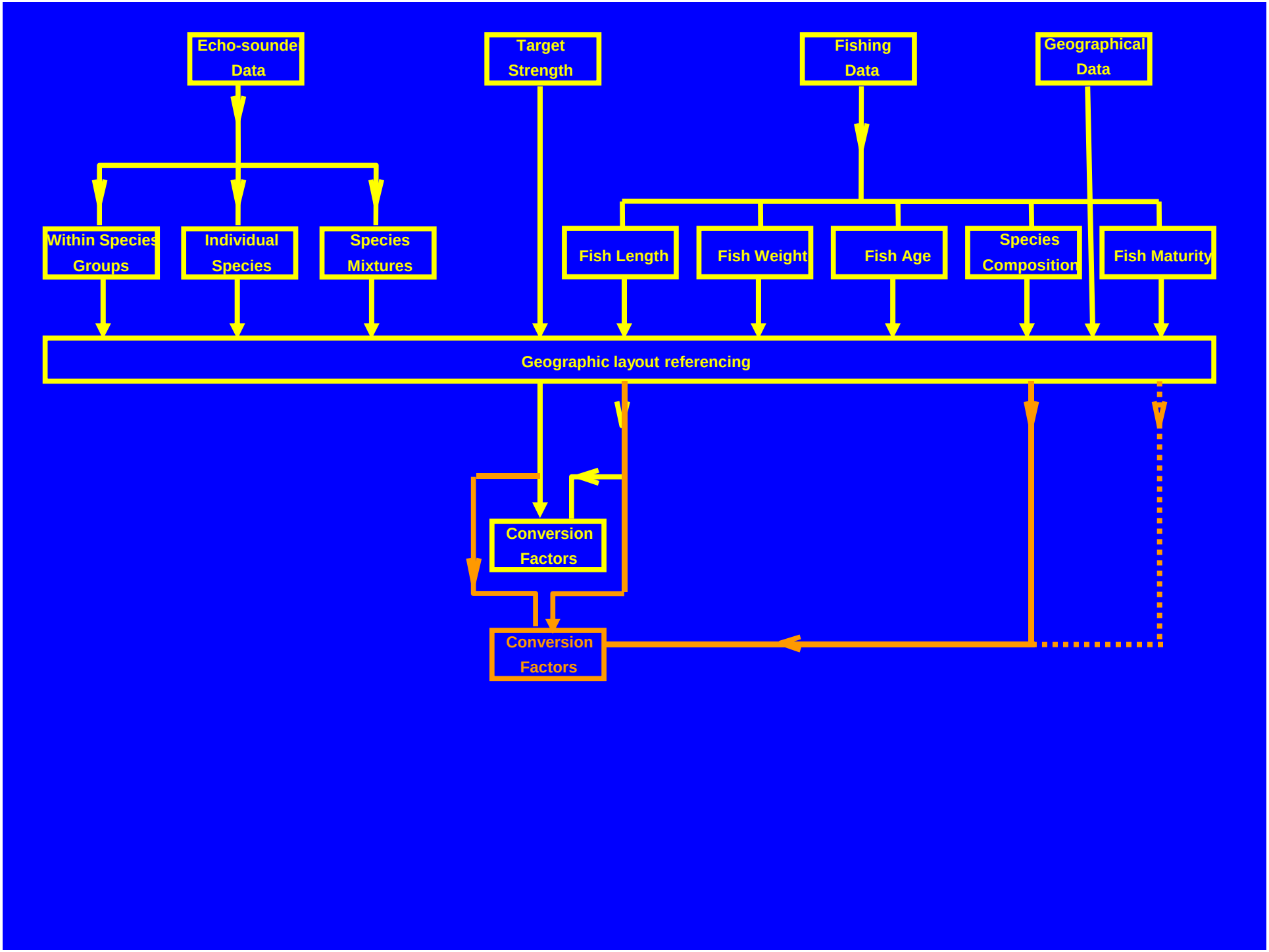
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Backscattering Crossection

- From TS relationships and length
- From TS data
- For multispecies combinations
- Relationships might depend on other biological / distributional factors (e.g. maturity stage / fish depth)

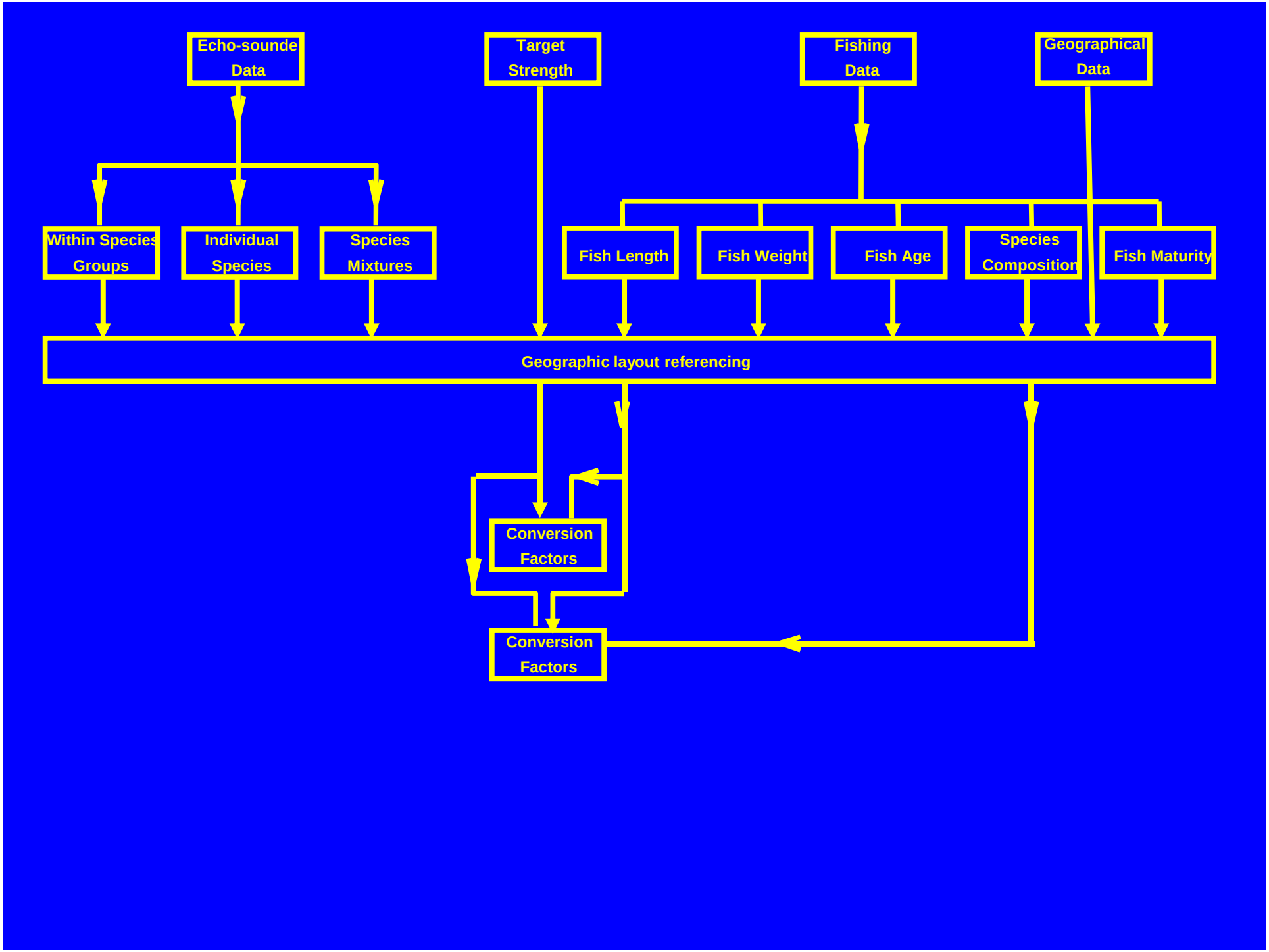
Calculation of mean Acoustic Cross-section

- Single species
  - TS = a + b log(L)
  - σ_{bs} = 10 ^{[a + b log (L)]/10}
  - Calculate for length distribution n_i at L_i
  - $\langle\sigma_{bs}\rangle = \Sigma\, n_i\, 10\ ^{\{[a + b \log (L_i)]/10\}} / \Sigma\, n_i$
- Combine for multiple species j with length frequency distribution n_{ij} at length L_{ij}
  - $\langle\sigma_{bs}\rangle = [\, \Sigma\, n_{ij}\, 10\ ^{\{[a_j + b_j \log (L_{ij})]/10\}} / \Sigma\, n_{ij}\,]$
  - Mean TS = 10 log $\{\langle\sigma_{bs}\rangle\}$

Calculation of mean Acoustic Cross-section

- Combine for species j with length frequency distribution n_{ij} at length L_{ij}

$$\langle \sigma_{bs} \rangle = [\, \Sigma\, n_{ij}\, 10\, \hat{}\{[a_j + b_j \log (L_{ij})]/10\} \,/\, \Sigma\, n_{ij}\,]$$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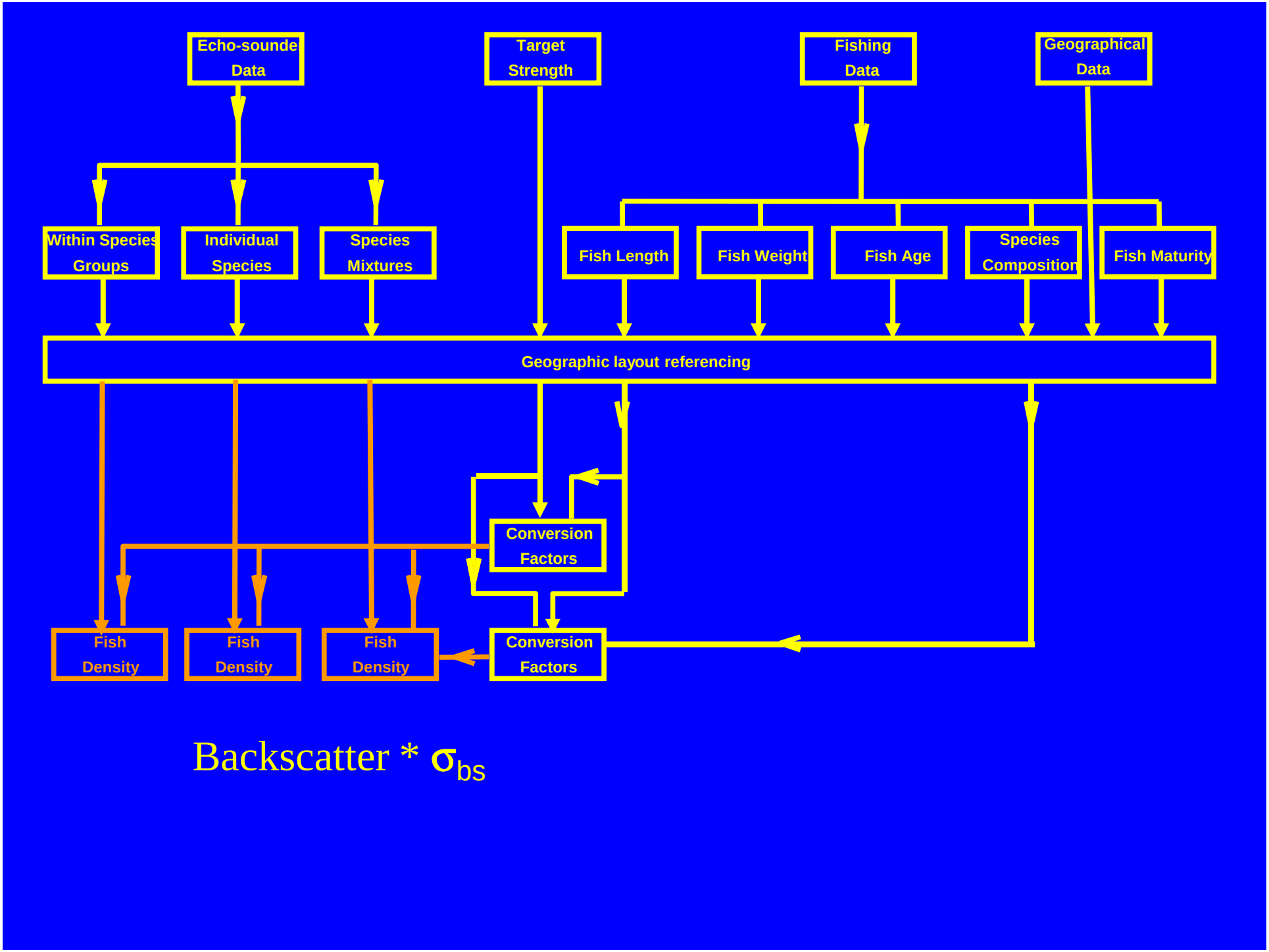
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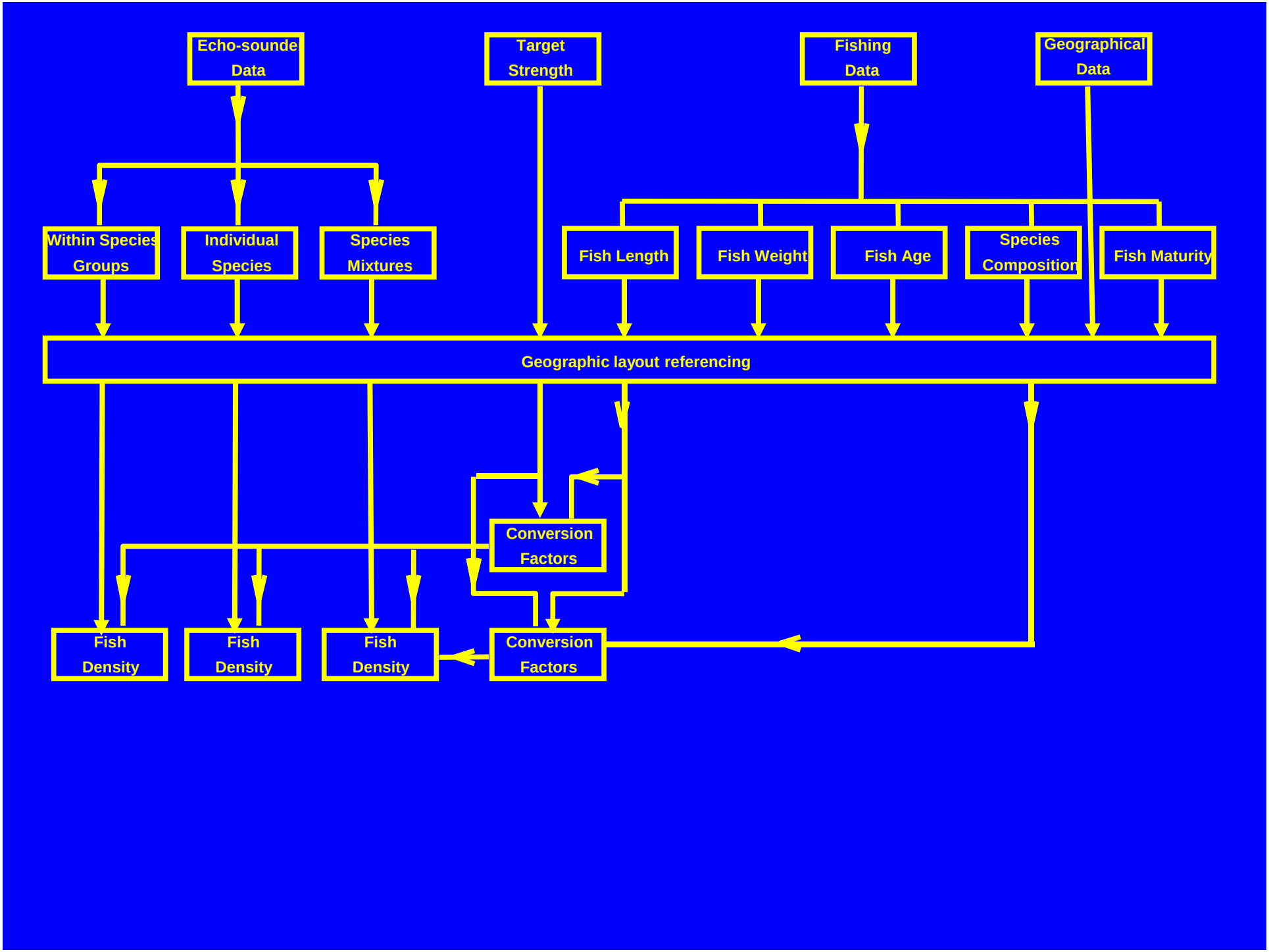
Backscatter * σ_{bs}

Estimating Abundance

- Density = Echo Integrator Output / Backscattering Cross-section
- Number density $\rho = s_a / \sigma_{bs}$ (Number m^{-2})
- or $\rho = 10^6 s_a / \sigma_{bs}$ (Number km^{-2})
- For EK 60 echosounder s_A

- $s_A = s_a \, 4\pi \, 1852^2$
- Then Number density $\rho = s_A / \sigma_{sp}$ (Number $N.mi.^{-2}$)
  where σ_{sp} is the spherical scattering cross section
- or $\rho = s_A / 4\pi\sigma_{bs}$ (Number $N.mi.^{-2}$)
- or $\rho = s_A / [4\pi\sigma_{bs}(1.852)^2]$ (Number km^{-2})
- Requires estimate of σ_{sp} or σ_{bs}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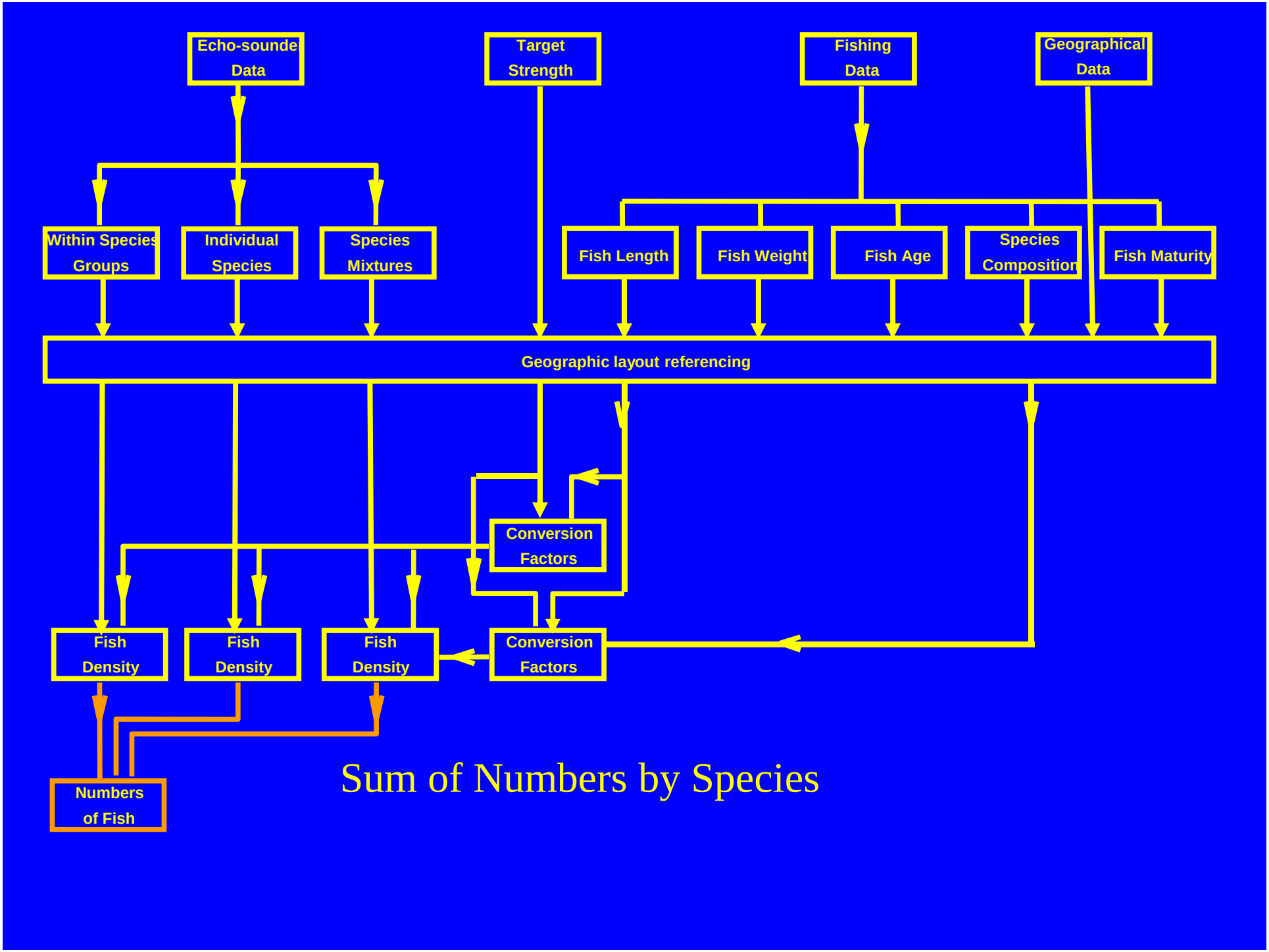
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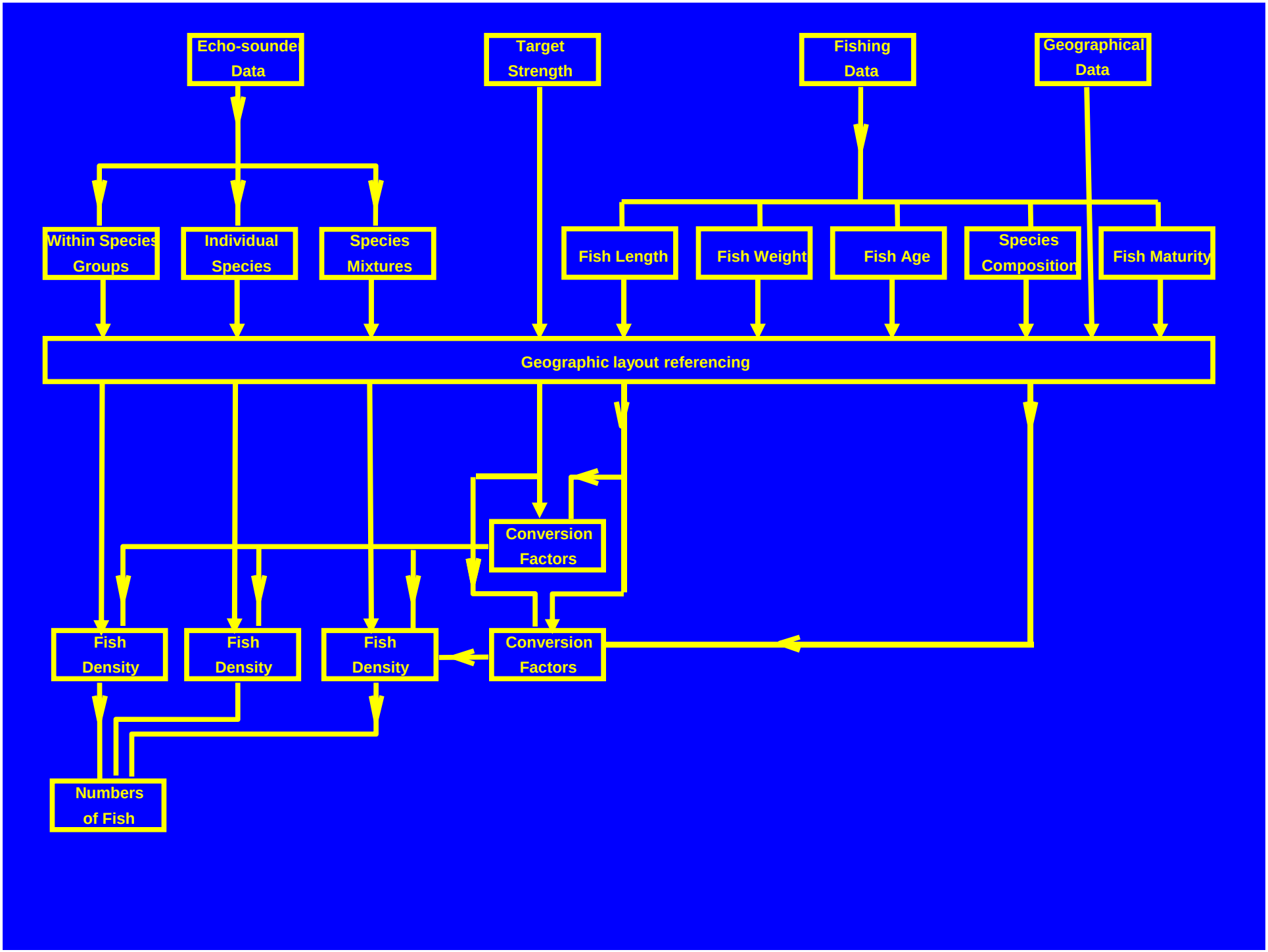
Conversion Factors
Numbers of Fish
Sum of Numbers by Species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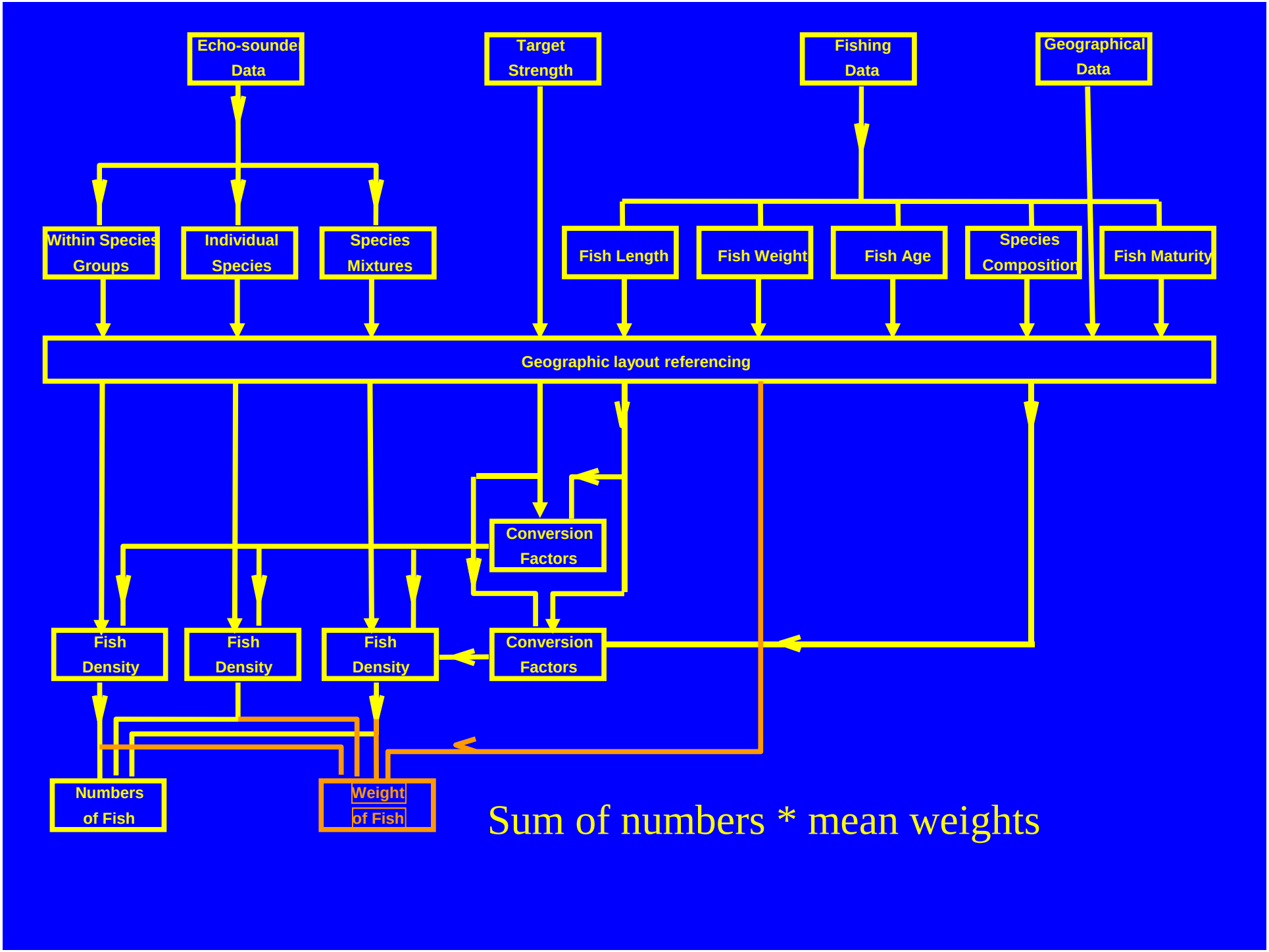
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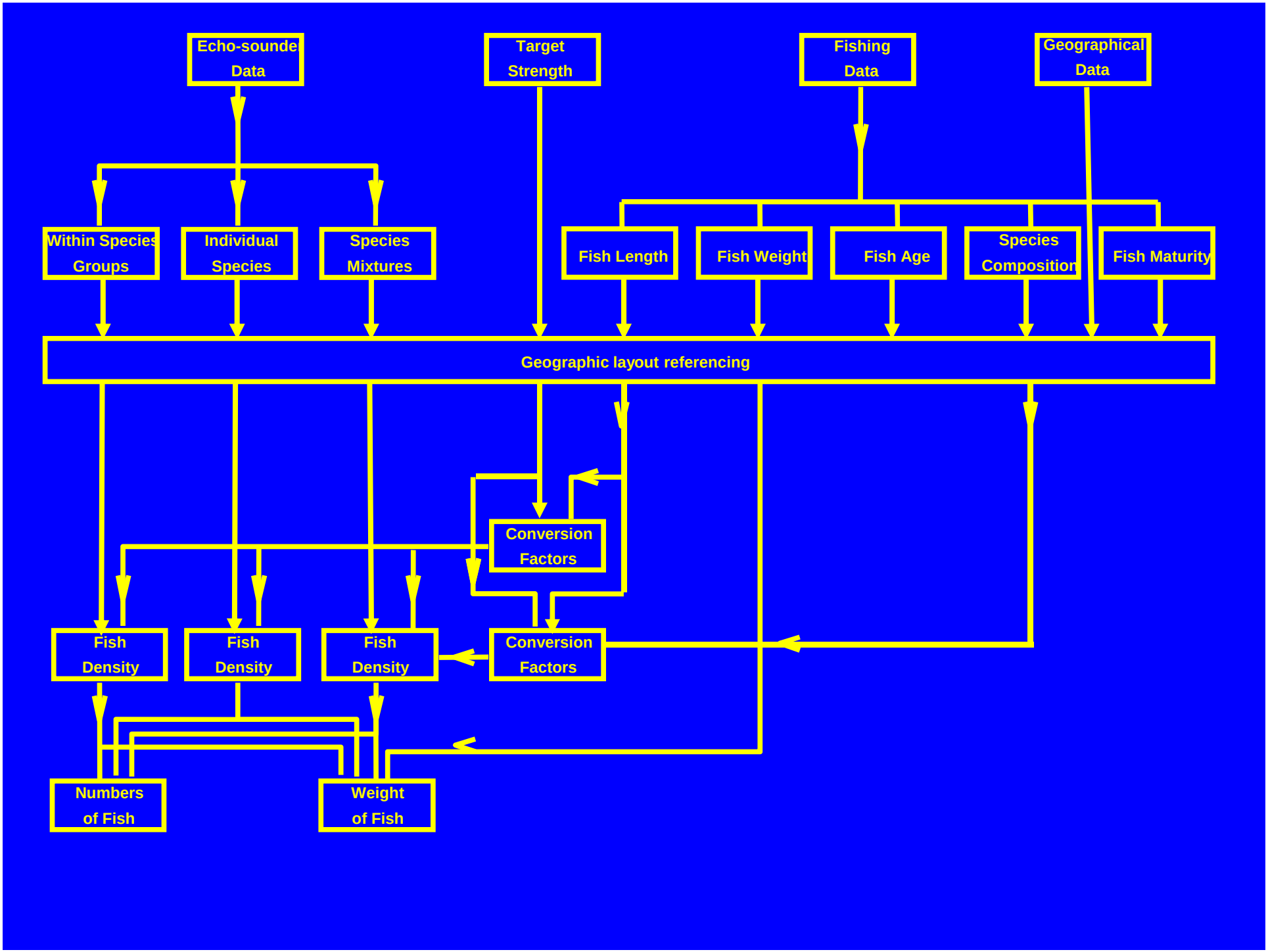
Conversion Factors
Numbers of Fish
Weight of Fish
Sum of numbers * mean weights

Converting Numbers to Biomass

- Biomass = Numbers . mean weight
- B = N . W
- if N in millions
- and W in grams
- B is in tonnes
- If N is per unit area B is for the same unit of area

- Weights may be calculated as:
  - Mean weight per fish measured
  - Mean weight using the Length Frequency Distribution and Length/ Weight relationship.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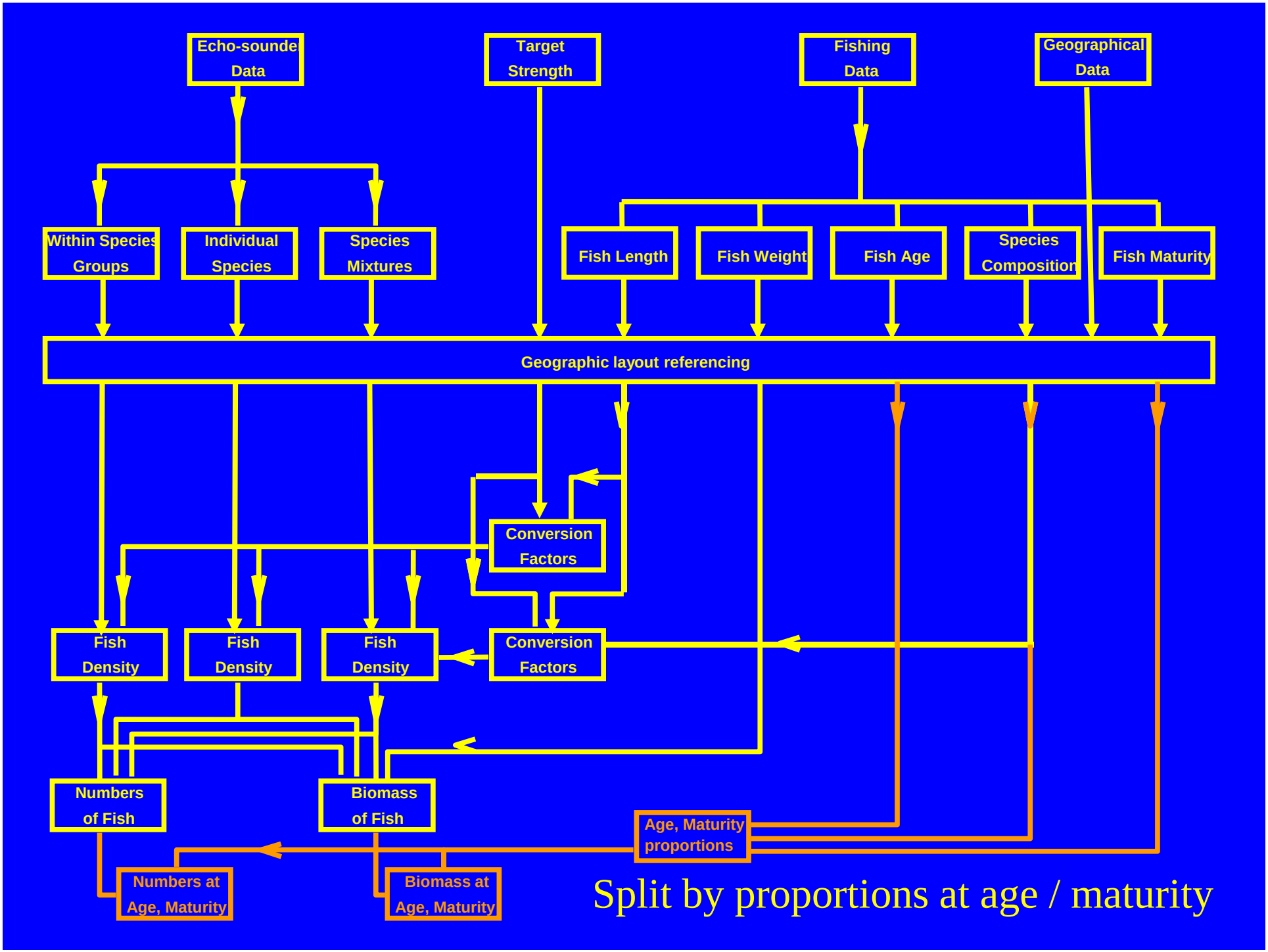
Numbers of Fish
Weight of Fish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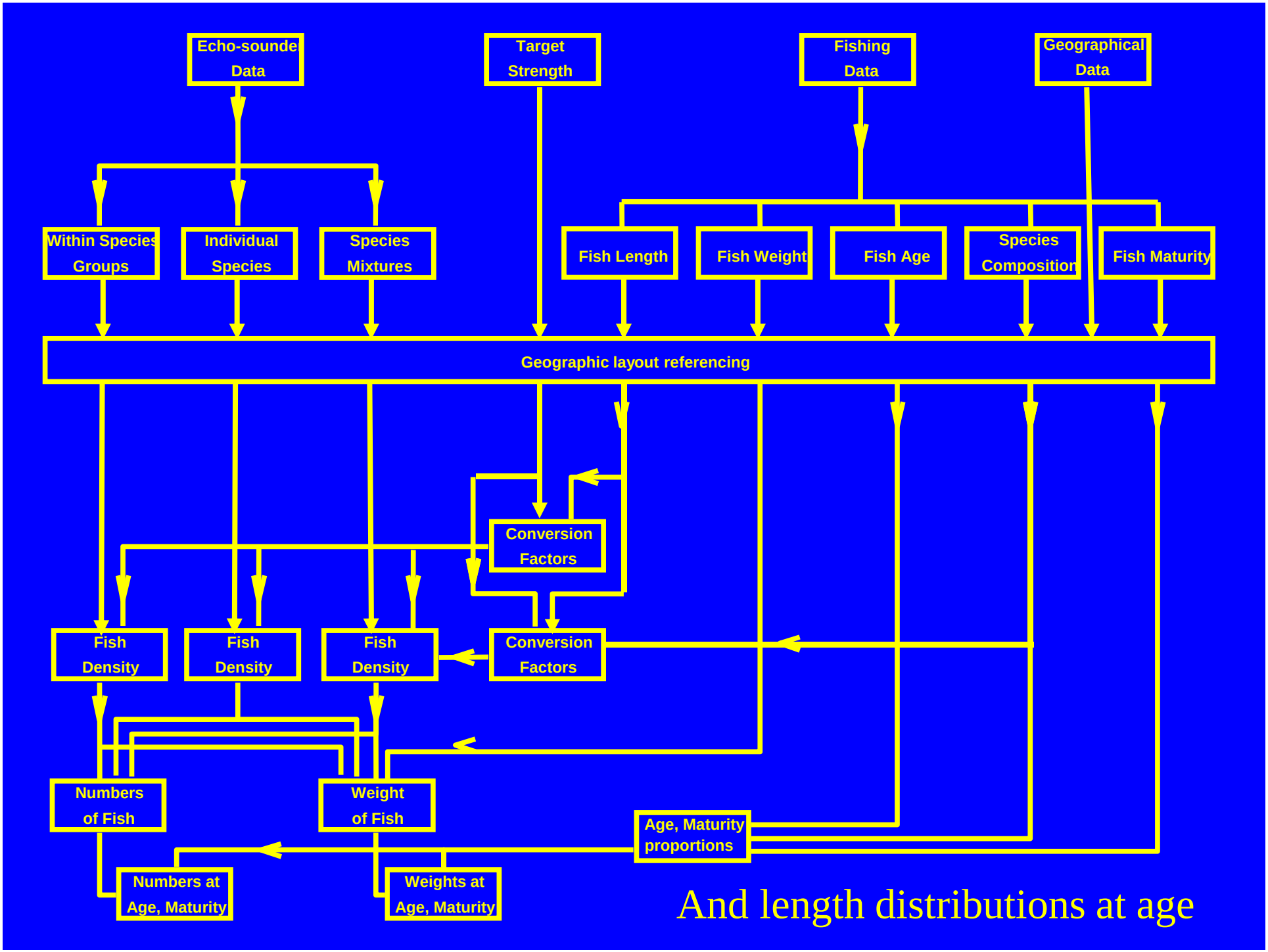
Numbers of Fish
Biomass of Fish
Age, Maturity proportions
Numbers at Age, Maturity
Biomass at Age, Maturity
Split by proportions at age / maturity

Splitting Stock by Age and or Maturity

- For Numbers
  - Multiply Numbers by
  - Fraction at age
  - Fraction mature
- For Biomass at age or maturity
  - Take Numbers at age or maturity
  - Multiply by mean weight at age or maturity stage
- SSB = Sum of biomass mature fish over all ages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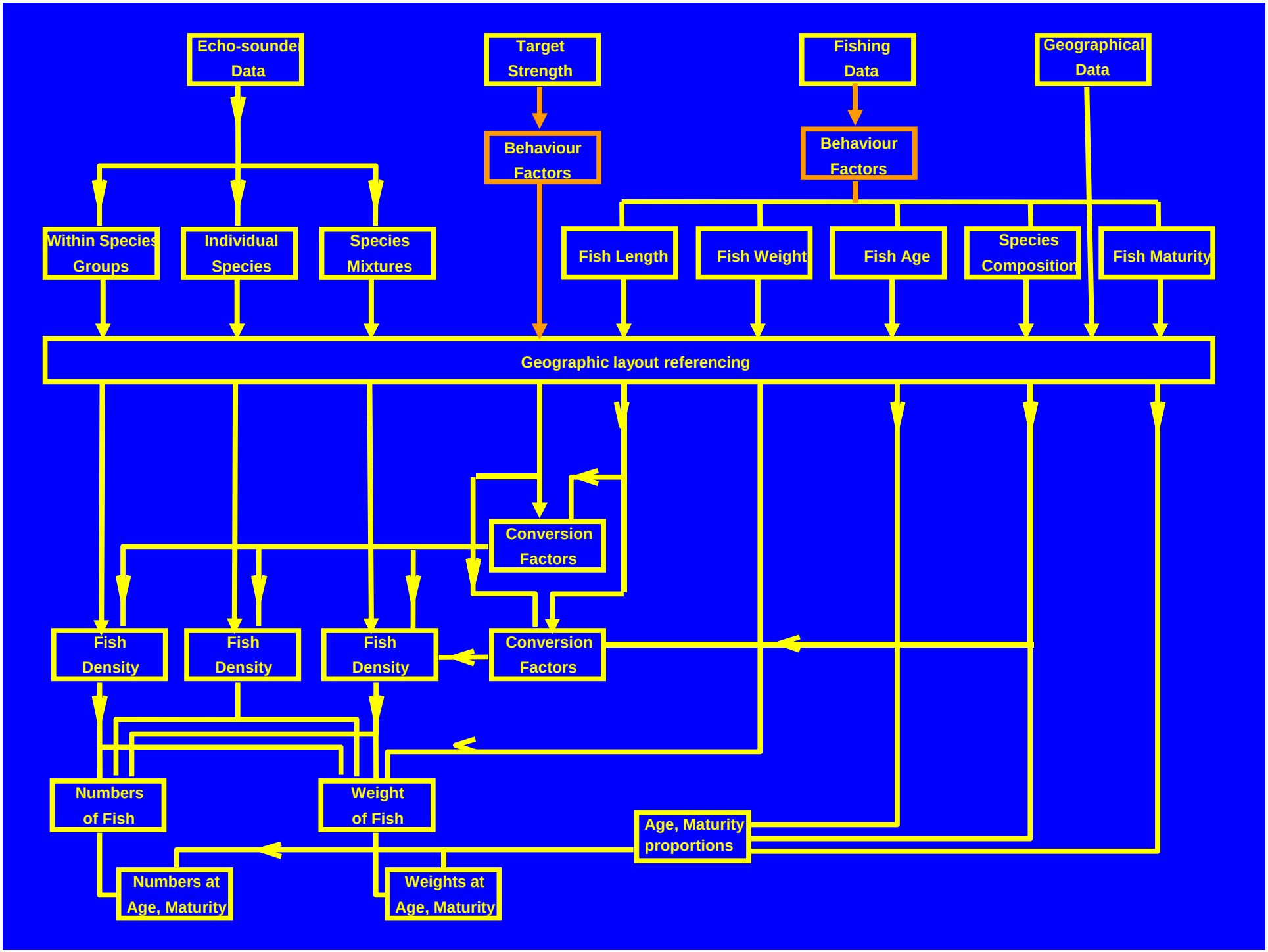
Weight of Fish
Age, Maturity proportions
Numbers at Age, Maturity
Weights at Age, Maturity
And length distributions at age

Inclusion of Behaviour effects ?

- TS effects
- Fishing effects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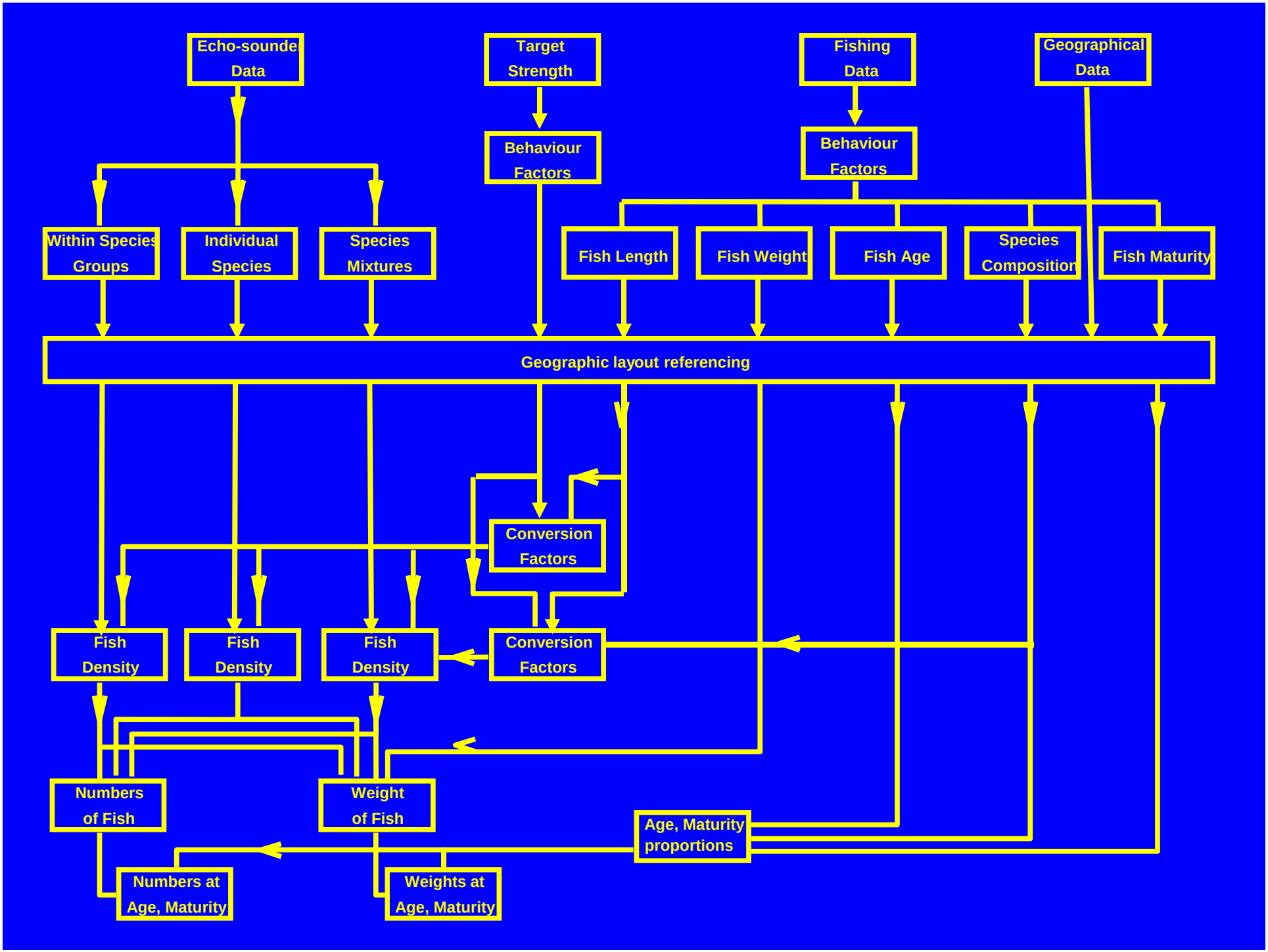
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Output Structure

- Maps
- Regional means
- Documentation
  - Analysis Date / Time Documented
    Analysis structure / choices

Summary of analysis

- Obtain echo integrator data for classified categories
- Correct for any calibration errors
- Decide on how area may be partitioned into regions or mapped for single species and multiple species
- Calculate mean length distribution for region
- Calculate $< \sigma_{bs} >$ for each region
- Calculate density (numbers per unit area) from echo integrator output and $< \sigma_{bs} >$
- Calculate area of each region
- Obtain abundance (Numbers / unit area * Area)
- Calculate Mean Weights
- Calculate Biomass (Numbers * Mean Weight)
- Split by age and/or other biological characteristics