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Population Hypotheses and Stock Assumptions for North Atlantic Bluefin Tuna

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SUMMARY

KEYWORDS: Bluefin, North Atlantic, Mediterranean, Stock, Population, Mixing, Management Strategy Evaluation

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1. Introduction

North Atlantic bluefin tuna *(Thunnus thynnus)* (BFT) is currently managed as two separate eastern and western stocks. However, tagging, micro-chemistry and genetic studies suggest that the stocks mix and within a stock there are sub components. Differences are also assumed in life history parameters, e.g. maturity and natural mortality, used in their stock assessments.

We review population hypotheses and discuss the importance of the population hypotheses for the current and alternative management framework. We then specify equations to map the population components into the current and alternative management units and discuss how to construct an Operating Model (OM) to be used as part of a Management Strategy Evaluation (MSE).

The currently assumed stock structure and management units are summarised in figure 1.

2. Hypotheses

2.1 Populations

[Population and life history hypotheses the from BFT-Bio report]

A variety of biological population structures have been proposed for BFT. The population structures diagrams 2 were developed during the Bluefin meeting on biological parameters (ref xxx). These assume that population components are self-reproducing entities (populations and sub-populations) with similar lifetime migration behaviors, which do not necessarily depend on reproductive isolation (contingents). The population structures are not intended to be exhaustive: alternative combinations of sub-populations and contingents could be proposed. The intention is to specify the main potential population structures that can be tested with existing data and used to build an OM.

The five hypotheses are

1. Two population model with no sub-populations
2. Two population model with contingents
3. Metapopulation model
4. Panmictic population with some patchiness
5. Extended West Atlantic two population model with contingents

2.2 Life History

2.21 Growth

2.22 Spawning Reproductive Potential

2.23 Natural Mortality

3. Methodology

[Discuss how to construct an OM to test current and alternative management]

3.1 Models

3.11 Variables

[List the variables]

3.12 Equations

[Specify the equations]

3.2 Implementation

3.21 Software

[How to code in C++ and R]

3.22 Documentation

[Use Oxygen to document all code]

3.23 Interface

[Object Orientating Programming in C++ for developers, and S4 in R for users and MP developers]

4. Discussion and Conclusions

[A list of all terminology]

References

[A Full literature review]

5. Tables

Table 1: Variables

i	age
j	year
k	unit
l	season
m	area

[Need to add indices for unit, area, season
And add other proceses etc.]

Table 2: Equations

Population dynamics

$$N_{a+1,y+1} = N_{a,y} e^{-Z_{a,y}} \tag{1}$$

$$N_{p,y} = N_{p-1,y-1} e^{-Z_{p-1,y-1}} + N_{p,y} e^{-Z_{p,y-1}} \tag{2}$$

$$N_{r,y} = f(B_{y-r}) \tag{3}$$

Mortality rates

$$Z_{a,y} = F_{a,y} + D_{a,y} + M_{a,y} \tag{4}$$

$$F_{a,y} = \sum_{i=1}^{f} P_{i,a,y} S_{i,a,y} E_{i,y} \tag{5a}$$

$$D_{a,y} = \sum_{i=1}^{f} \left(1 - P_{i,a,y}\right) S_{i,a,y} E_{i,y} \tag{5b}$$

Catch equation

$$C_{f,a,y} = N_{a,y} \frac{F_{f,a,y}}{Z_{f,a,y}} \left(1 - e^{-Z_{a,y}}\right) \tag{6}$$

Stock recruitment relationships

Beverton & Holt

$$N_{r,y} = \frac{B_{y-r}}{\alpha B_{y-r} + \beta} \tag{7}$$

Growth and maturity

von Bertalanffy

$$N_{r,y} = \frac{B_{y-r}}{\alpha B_{y-r} + \beta} \tag{8}$$

6. Figures

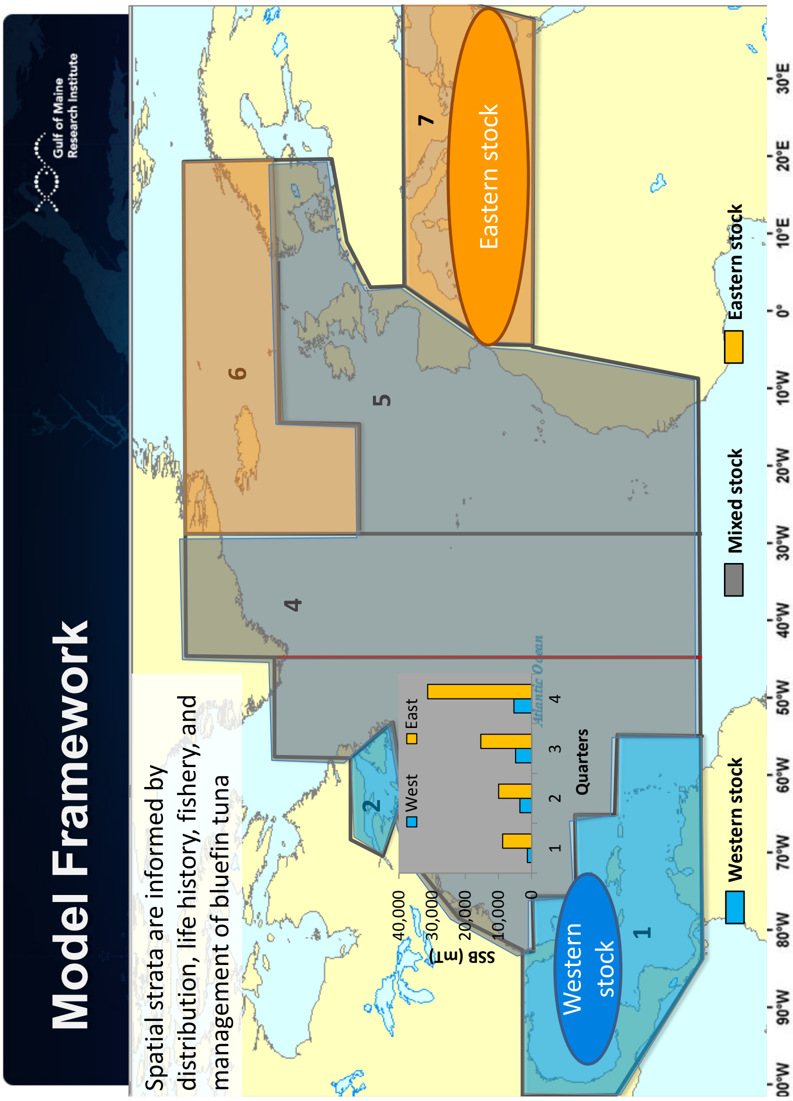

Figure 1: **Spatial strata as informed by distribution, life history, fishery, and management of bluefin tuna**

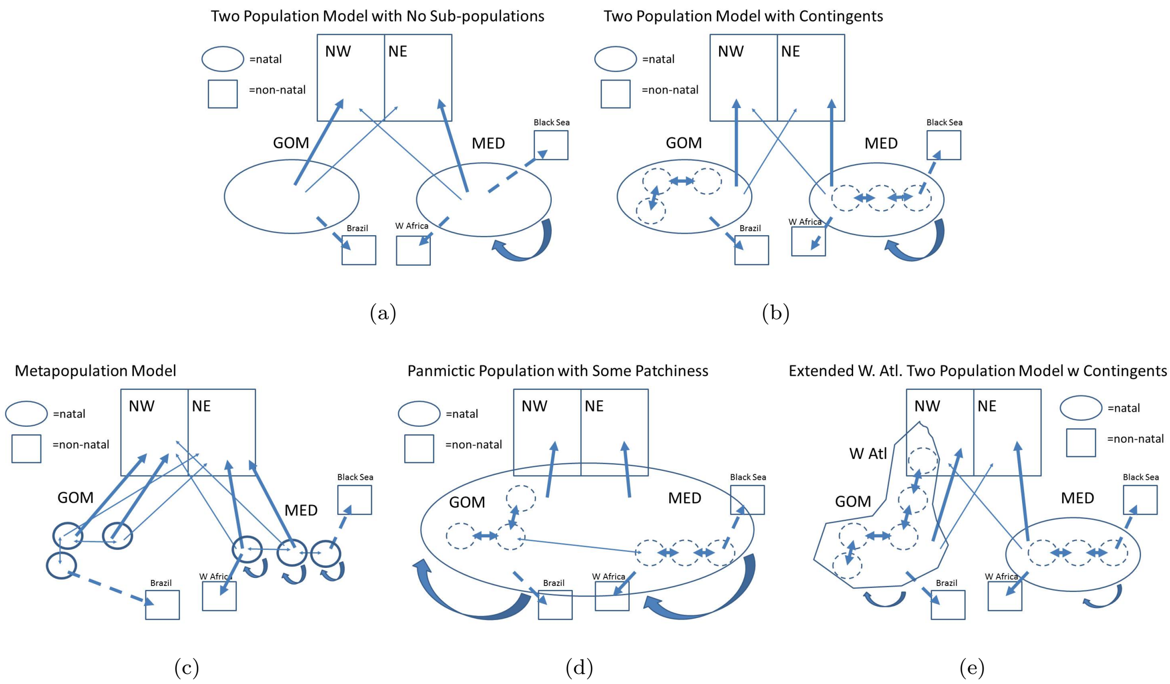

Figure 2: Population Hypotheses

Glossary

biological population A self-sustaining group of individuals, from a single species, whose dynamics are primarily determined by birth and death processes.

Acronyms

BFT North Atlantic bluefin tuna *(Thunnus thynnus)*. 3

MSE Management Strategy Evaluation. 3

OM Operating model is a mathematicalstatistical model used to describe the actual resource dynamics in simulation trials and to generate resource monitoring data when projecting forward.. 3