LW FINAL CANDIDATE MANAGEMENT PROCEDURE; TUNED TO ABT_MSE PACKAGE 7.8.4

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SUMMARY

The LW CMP showed better performance over the PW CMP, primarily in terms of higher yields while also meeting safety targets for the stocks, and therefore is selected as the single final procedure supported by the analysts. This report provides documentation of the final LW procedure for the East and West areas. The procedure was tuned (ABT_MSE v7.8.4) to the 60% and 70% probability of green Kobe status (PGK) for 2- and 3-year management cycles, with a maximum TAC increase of 20% and decrease of 30% between cycles. A phase-in period included two management cycles under a 2-yr cycle, or one management cycle for 3-yr cycle, where a maximum TAC decrease of 10% was applied, thereafter returning to 30% maximum base assumption. The results are included in the final summaries available online with the links provided within the report results section.

RÉSUMÉ

RESUMEN

KEYWORDS

Atlantic bluefin tuna, Management strategy evaluation, Candidate management procedure

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1. Introduction

A management strategy evaluation (MSE) for Atlantic bluefin tuna has been under development by ICCAT and contracted technical experts for the last several years as part of the Atlantic-wide Research Programme for Bluefin Tuna. The MSE provides a flexible simulation framework to test alternative strategies for managing harvest of Atlantic bluefin tuna in the East and West Atlantic. One of the strengths of the MSE is the alternative parameterizations of recruitment, natural mortality, and stock mixing (shown to have large effects on the stock assessments) programmed into the model. This flexibility allows for testing of how different procedures perform under alternative scenarios of stock biology and fisheries dynamics. The report provides documentation of the final LW procedure for the West and East Atlantic areas.

2. Methods and Results

The LW CMP was tuned to six scenarios in the ABT_MSE R package, version 7.8.4:

1. LW5a: 60% PGK (E and W), 2-yr management cycle, 20% increase max, 30% decrease max, 2-cycle phase-in with 10% decrease max
2. LW5b: 60% PGK (E and W), 3-yr management cycle, 20% increase max, 30% decrease max, 1-cycle phase-in with 10% decrease max
3. LW5c: 60% PGK (E and W), 3-yr management cycle, 20% increase max, 35% decrease max, 1-cycle phase-in with 10% decrease max
4. LW6a: 70% PGK (E and W), 2-yr management cycle, 20% increase max, 30% decrease max, 2-cycle phase-in with 10% decrease max
5. LW6b: 70% PGK (E and W), 3-yr management cycle, 20% increase max, 30% decrease max, 1-cycle phase-in with 10% decrease max
6. LW7b: same as LW5b, but with PGK East tuned upward to meet LD15%=0.4 (not achieved in LW5b)

The final tuning parameters for the six scenarios were:

LW5a: East=2.30, West=0.895

LW5b: East=2.345, West=0.88

LW5c: East=2.50, West=0.885

LW6a: East= 1.87, West=0.74

LW6b: East=1.89, West=0.74

LW7b: East=2.15, West=0.90

The results are summarized in conjunction with all other final CMPs, available on the project Shiny application websites here for main results page: https://apps.bluematterscience.com/ABTMSE/, and the summary statistic table (i.e. quiltplots) here: https://apps.bluematterscience.com/ABTMSE_Performance2/. The following sections document the final LW procedure applied to the West and East areas under each of the six scenarios. The R code to implement the LW CMP in the ABT_MSE package is included in Appendix A for the 2-yr cycle, and Appendix B for the 3-yr cycle procedure.

2.1. WEST AREA PROCEDURE

A target index value for the West Atlantic area is calculated as the ratio of average catches to a summed average relative abundance metric for both stocks:

$$I_{WATL\_target} = \frac{\overline{Catch}_{WATL\_2016-2018}}{\overline{CPUE}_{GoM\_2016-2018} + \overline{CPUE}_{Med\_2016-2018}}$$

where

I_{WATL_target} is a target relative harvest rate index for the West Atlantic area

CPUE are the standardized index values for the stock biomass, divided by the mean of the CPUE time series up to year 2018.

A current index value for the West Atlantic area is calculated as the ratio of average recent catches to a summed recent average relative abundance metric for both stocks:

$$I_{WATL\_current} = \frac{\overline{Catch}_{WATL_{t-2:t}}}{\overline{CPUE}_{GoM\_t-2:t} + \overline{CPUE}_{Med\_t-2:t}}$$

where

$I_{WATL\_current}$ is a current relative harvest rate index value for the West Atlantic area

t = terminal year of current index

CPUE is standardized index values for the stock biomass, divided by the mean of the CPUE time series up to year 2018.

The ratio of the target to current index (Δ) is then calculated and multiplied by a tuning parameter (α) of the target index:

$$\Delta_{WATL\_i} = \frac{\alpha \cdot I_{WATL\_target}}{I_{WATL\_current}}$$

Two separate Δ values are calculated using alternative sets of CPUE series (i). The first index uses the larval surveys in the Gulf of Mexico and Mediterranean Sea, and the second set of indices uses the MEXUS LL and JPN LL EATL. The mean of the two Δ values is then calculated to get an overall West area TAC estimated change.

$$West\ Area\ new\ TAC = TAC_{t-2:t} \cdot \frac{\Delta_{WATL\_1} + \Delta_{WATL\_2}}{2}$$

Each TAC is then subject to the constraints of 20% max increase, 30% max decrease, and the phase-in limit of 10% max decrease during the first two implementations for a 2-yr cycle, or one cycle implementation under the 3 years per cycle scenario.

2.2 EAST AREA PROCEDURE

Similar to the West Area, a target index value for the East Atlantic area is calculated as the ratio of average catches to an average relative abundance series, but only for the Med stock biomass:

$$I_{EATL\_target} = \frac{\overline{Catch}_{EATL\_2016-2018}}{\overline{CPUE}_{Med\_2016-2018}}$$

where

I_{EATL_target} is a target relative harvest rate index for the East Atlantic area

CPUE are the standardized index values for the stock biomass, divided by the mean of the CPUE time series up to year 2018.

A current index value for the East Atlantic area is calculated as the ratio of average catches to a summed average relative abundance for the East stock:

$$I_{EATL\_current} = \frac{\overline{Catch}_{EATL_{t-2:t}}}{\overline{CPUE}_{Med\_t-2:t}}$$

where

$I_{EATL\_current}$ is a current relative harvest rate index base value for the East Atlantic area

t = terminal year of current index

CPUE is standardized index values for the Med stock biomass, divided by the mean of the CPUE time series up to year 2018.

The ratio of the target to current index (Δ) is then calculated and multiplied by a tuning parameter (β) of the target index:

$$\Delta_{EATL\_i} = \frac{\beta \cdot I_{EATL\_target}}{I_{EATL\_current}}$$

Two separate Δ values are calculated using alternative CPUE series (i). The first index uses the larval survey in the Mediterranean Sea, and the second index uses the JPN LL EATL. The mean of the two Δ values is then calculated to get an overall East TAC estimated change.

$$East\ Area\ new\ TAC = TAC_{t-2:t} \cdot \frac{\Delta_{EATL\_1} + \Delta_{EATL\_2}}{2}$$

Each TAC is then subject to the constraints of 20% max increase, 30% max decrease, and the phase-in limit of 10% max decrease during the first two implementations (2-yr cycle).

APPENDIX A. R code for the LW CMP with a 2-yr management cycle.

```
ConstU_W <-
function(x,dset,IndexE=c(2,6),IndexW=c(3,14),yrs4mean=3,target_yr=54,deltaW_up=0.2,deltaW_down=0.3,m
ultiplierW=tune_parW,Method='mean')
        {
        phase_down=0.1

        target_yrs=target_yr-(yrs4mean-1):0
        Ny = ncol(dset$Cobs)

        delta_ratios=matrix(nrow=1, ncol=length(IndexE))
        for(i in 1:length(IndexW))
                {

        targetI=mean(dset$Iobs[x,IndexW[i],target_yrs],na.rm=TRUE)/mean(dset$Iobs[x,IndexW[i],1:target_
yr],na.rm=TRUE)+

        mean(dset$Iobs[x,IndexE[i],target_yrs],na.rm=TRUE)/mean(dset$Iobs[x,IndexE[i],1:target_yr],na.rm=
TRUE)
                targetC=mean(dset$Cobs[x,target_yrs],na.rm=TRUE)
                targetU=multiplierW*targetC/targetI
                lastyr=dim(dset$Iobs)[3]
                datayrs=lastyr-(yrs4mean-1):0

        curI=mean(dset$Iobs[x,IndexW[i],datayrs],na.rm=TRUE)/mean(dset$Iobs[x,IndexW[i],1:target_yr],na
.rm=TRUE)+

        mean(dset$Iobs[x,IndexE[i],datayrs],na.rm=TRUE)/mean(dset$Iobs[x,IndexE[i],1:target_yr],na.rm=T
RUE)
                curC=mean(dset$Cobs[x,datayrs],na.rm=TRUE)
                curU=(curC/curI)
                delta_ratios[i]=targetU/curU
                }
        delta_ratio=apply(delta_ratios,1,FUN=Method)
        oldTAC = dset$MPrec[x]

        if(Ny < 60)
                {
                if(delta_ratio<1)
                        {
                        TAC=max(oldTAC*delta_ratio,oldTAC*(1-phase_down))
                        }
                else
                        {
                        TAC=min(oldTAC*delta_ratio,oldTAC*(1+deltaW_up))
                        }
                }
        else
                {
                if(delta_ratio<1)
                        {
                        TAC=max(oldTAC*delta_ratio,oldTAC*(1-deltaW_down))
                        }
                else
                        {
                        TAC=min(oldTAC*delta_ratio,oldTAC*(1+deltaW_up))
                        }
                }
        }
```

```
class(ConstU_W)<-"MP"

ConstU_E <- function(x,dset,IndexE=c(2,6),yrs4mean=3,target_yr=54,deltaE_up=0.2,
deltaE_down=0.3,multiplierE=tune_parE,Method="mean")
	{
	phase_down=0.1

	target_yrs=target_yr-(yrs4mean-1):0
	Ny = ncol(dset$Cobs)

	delta_ratios=matrix(nrow=1, ncol=length(IndexE))
	for(i in 1:length(IndexE))
		{

	targetI=mean(dset$Iobs[x,IndexE[i],target_yrs],na.rm=TRUE)/mean(dset$Iobs[x,IndexE[i],1:target_yr
],na.rm=TRUE)
		targetC=mean(dset$Cobs[x,target_yrs],na.rm=TRUE)
		targetU=multiplierE*(targetC/targetI)
		lastyr=dim(dset$Iobs)[3]
		datayrs=lastyr-(yrs4mean-1):0

	curI=mean(dset$Iobs[x,IndexE[i],datayrs],na.rm=TRUE)/mean(dset$Iobs[x,IndexE[i],1:target_yr],na.r
m=TRUE)
		curC=mean(dset$Cobs[x,datayrs],na.rm=TRUE)
		curU=curC/curI
		delta_ratios[i]=targetU/curU
		}
	delta_ratio=apply(delta_ratios,1,FUN=Method)

	oldTAC = dset$MPrec[x]
	if(Ny<60)
		{
		if(delta_ratio<1)
			{
			TAC=max(oldTAC*delta_ratio,oldTAC*(1-phase_down))
			}
		else
			{
			TAC=min(oldTAC*delta_ratio,oldTAC*(1+deltaE_up))
			}
		}
	else
		{
		if(delta_ratio<1)
			{
			TAC=max(oldTAC*delta_ratio,oldTAC*(1-deltaE_down))
			}
		else
			{
			TAC=min(oldTAC*delta_ratio,oldTAC*(1+deltaE_up))
			}
		}


	}
class(ConstU_E)<-"MP"

NOAA_CMPs<-list(c('ConstU_E','ConstU_W'))
```

APPENDIX B. R code for the LW CMP with a 3-yr management cycle.

```
ConstU_W <-
function(x,dset,IndexE=c(2,6),IndexW=c(3,14),yrs4mean=3,target_yr=54,deltaW_up=0.2,deltaW_down=0.3,m
ultiplierW=tune_parW,Method='mean')
        {
        phase_down=0.1

        target_yrs=target_yr-(yrs4mean-1):0
        Ny = ncol(dset$Cobs)

        delta_ratios=matrix(nrow=1, ncol=length(IndexE))
        for(i in 1:length(IndexW))
                {

        targetI=mean(dset$Iobs[x,IndexW[i],target_yrs],na.rm=TRUE)/mean(dset$Iobs[x,IndexW[i],1:target_
yr],na.rm=TRUE)+

        mean(dset$Iobs[x,IndexE[i],target_yrs],na.rm=TRUE)/mean(dset$Iobs[x,IndexE[i],1:target_yr],na.rm=
TRUE)
                targetC=mean(dset$Cobs[x,target_yrs],na.rm=TRUE)
                targetU=multiplierW*targetC/targetI
                lastyr=dim(dset$Iobs)[3]
                datayrs=lastyr-(yrs4mean-1):0

        curI=mean(dset$Iobs[x,IndexW[i],datayrs],na.rm=TRUE)/mean(dset$Iobs[x,IndexW[i],1:target_yr],na
.rm=TRUE)+

        mean(dset$Iobs[x,IndexE[i],datayrs],na.rm=TRUE)/mean(dset$Iobs[x,IndexE[i],1:target_yr],na.rm=T
RUE)
                curC=mean(dset$Cobs[x,datayrs],na.rm=TRUE)
                curU=(curC/curI)
                delta_ratios[i]=targetU/curU
                }
        delta_ratio=apply(delta_ratios,1,FUN=Method)
        oldTAC = dset$MPrec[x]

        if(Ny < 59)
                {
                if(delta_ratio<1)
                        {
                        TAC=max(oldTAC*delta_ratio,oldTAC*(1-phase_down))
                        }
                else
                        {
                        TAC=min(oldTAC*delta_ratio,oldTAC*(1+deltaW_up))
                        }
                }
        else
                {
                if(delta_ratio<1)
                        {
                        TAC=max(oldTAC*delta_ratio,oldTAC*(1-deltaW_down))
                        }
                else
                        {
                        TAC=min(oldTAC*delta_ratio,oldTAC*(1+deltaW_up))
                        }
                }
        }
```

```
class(ConstU_W)<-"MP"

ConstU_E <- function(x,dset,IndexE=c(2,6),yrs4mean=3,target_yr=54,deltaE_up=0.2,
deltaE_down=0.3,multiplierE=tune_parE,Method="mean")
	{
	phase_down=0.1

	target_yrs=target_yr-(yrs4mean-1):0
	Ny = ncol(dset$Cobs)

	delta_ratios=matrix(nrow=1, ncol=length(IndexE))
	for(i in 1:length(IndexE))
		{

	targetI=mean(dset$Iobs[x,IndexE[i],target_yrs],na.rm=TRUE)/mean(dset$Iobs[x,IndexE[i],1:target_yr
],na.rm=TRUE)
		targetC=mean(dset$Cobs[x,target_yrs],na.rm=TRUE)
		targetU=multiplierE*(targetC/targetI)
		lastyr=dim(dset$Iobs)[3]
		datayrs=lastyr-(yrs4mean-1):0

	curI=mean(dset$Iobs[x,IndexE[i],datayrs],na.rm=TRUE)/mean(dset$Iobs[x,IndexE[i],1:target_yr],na.r
m=TRUE)
		curC=mean(dset$Cobs[x,datayrs],na.rm=TRUE)
		curU=curC/curI
		delta_ratios[i]=targetU/curU
		}
	delta_ratio=apply(delta_ratios,1,FUN=Method)

	oldTAC = dset$MPrec[x]
	if(Ny<59)
		{
		if(delta_ratio<1)
			{
			TAC=max(oldTAC*delta_ratio,oldTAC*(1-phase_down))
			}
		else
			{
			TAC=min(oldTAC*delta_ratio,oldTAC*(1+deltaE_up))
			}
		}
	else
		{
		if(delta_ratio<1)
			{
			TAC=max(oldTAC*delta_ratio,oldTAC*(1-deltaE_down))
			}
		else
			{
			TAC=min(oldTAC*delta_ratio,oldTAC*(1+deltaE_up))
			}
		}


	}
class(ConstU_E)<-"MP"

NOAA_CMPs<-list(c('ConstU_E','ConstU_W'))
```