GUIDE TO ESTIMATING TOTAL ALLOWABLE CATCH USING SIZE FREQUENCY IN CATCH, EFFORT DATA, AND MPAS

Contact

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Based on: Wilson, J.R., J.D. Prince, and H.S. Lenihan (2010): A Management Strategy for Sedentary Nearshore Species that Uses Marine Protected Areas as a Reference. Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science 2:14–27, 2010

Background

Catch per unit effort trends are often used to determine whether fish stock abundance is increasing, stable, or declining. However, they are often misleading because fishermen target fish, resulting in high CPUE even when stocks are declining. If the fish aggregate in schools or to spawn, CPUE trends can also be misleading, again because CPUE will be high even if the overall stock abundance is declining as fishermen target the aggregations.

Size frequency in the catch can be used to estimate the exploitation status of fish stocks (see our Guide to the use of Froese Sustainability Indicators for the Assessment and Management of Data-Limited Fish Stocks). However, these methods are limited by the lack of baseline data indicating what the size frequency of the stock should be if it was unfished. Moreover, size frequency data cannot currently be used to estimate what the Total Allowable Catch should be to maintain sustainable yields.

The method developed by Wilson et al. (2010) combines CPUE trend information with size frequency in the catch and baseline information on CPUE and size frequency from Marine Protected Areas where populations are unfished to generate improved estimates of Total Allowable Catch without extensive catch records or complex modeling.

Required Data

This method requires fishing surveys to collect catch per unit effort of three size classes of fish: recruits (0 - length at maturity), prime (length at maturity to 0.6 of maximum length), and old (length greater than 0.6 of maximum length) inside and outside of well enforced MPAs. Ideally, these surveys would be conducted randomly over a variety of habitat types inside and outside the MPAs, over a minimum of 5 years.

If no surveys are available, the catch can be sampled randomly. Effort should be recorded as fishing hours and divided into the number of fish in each size class to calculate CPUErecruits, CPUEprime, and CPUEold.

Current catches or the average catch in the last few years can be used to set an initial TAC. The decision tree approach adjusts this initial TAC in each successive year to achieve desired objectives in the fishery.

<u>Step 1: Estimate Initial TAC Using CPUEprime Inside and Outside of MPAs</u>

Vt = (At - theta(t)*Bt)/d

where Vt is the slope to the target SPR
At is CPUEprime in the fishing ground
Bt is CPUEprime in the MPA
d is the time required to rebuild the stocks within the MPA (about 10 years for most species)

Theta is the optimal fraction of CPUE outside the MPA to CPUE inside the MPA. Although it may vary for certain species, it is reasonable to suggest that a fraction of 0.4 will result in a productive, sustainable fishery. In other words, if the CPUE outside is 40% of the CPUE inside, the TAC is set appropriately.

Ideally, the MPA will be at least ten years old and well enforced to ensure that rebuilding of heavily fished stocks has taken place and stabilized. If this is the case, use the specified theta value of 0.4 (or higher if deemed appropriate). If only young MPAs are available, it may take many years for the population inside the MPA to approach “unfished” levels. If the MPAs are young, the initial TAC can still be improved by calculating a different theta value (theta (t+1)) during this phase in period:

theta(t+1) = theta(t) – (1-target ratio)/MGT

where MGT is the mean generation time of the species of interest and theta = 0.4 if the MPA is older than the MGT. To calculate MGT, see http://www.fishbase.us/manual/English/key%20facts.htm.

The improved TAC is then estimated as:

$TAC(t+1) = TAC(t) * [1 + k(Vt)]$

where k is a responsiveness factor (depending on how much managers adjust TAC in response to the slope to the target SPR); Wilson et al. (2010)) use k = 0.9, which should be OK for most fisheries.

Step 2: Compare CPUEprime on the Fishing Grounds with Average CPUEprime

First, calculate the average of CPUEprime over 5 years. If current CPUEprime is 5% or more below the average, CPUEprime is assumed to be declining. If current CPUEprime is 5% or more above the average, CPUEprime is assumed to be increasing. If CPUEprime is within 5% of the average, CPUEprime is assumed to be stable.

Step 3. Calculate CPUEold and the Proportion of Old Fish in the Catch and Compare with Targets

Step three requires outputs from a spreadsheet model (attached) estimating the spawning potential ratio for the fishery. The model requires estimates of von Bertalanffy growth parameters, fecundity at length, reproductive maturity at length, and selectivity to the gear at length. Spawning potential ratio (SPR) is the relationship between the egg production of a single individual over its lifetime at a given fishing mortality rate relative to the egg production that that individual would achieve with no fishing.

To calculate SPR please see the attached excel spreadsheet.

CPUEold is the catch of fish in the old size class divided by the effort (e.g. number of fishing hours) resulting in that catch. The target is calculated in the spreadsheet.

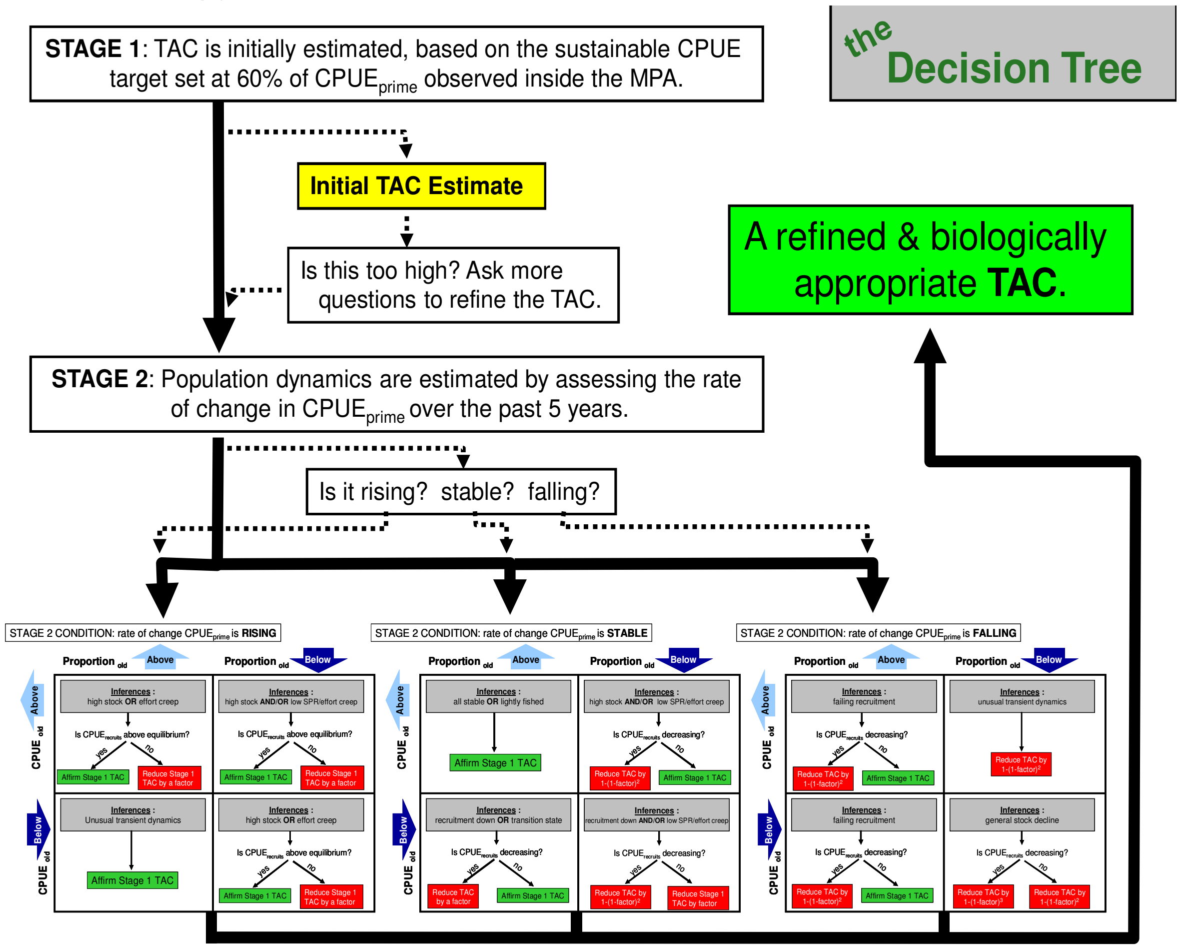
The proportion of old fish in the catch is the number of fish in the old size class divided by the total sample size. The target is calculated in the spreadsheet.

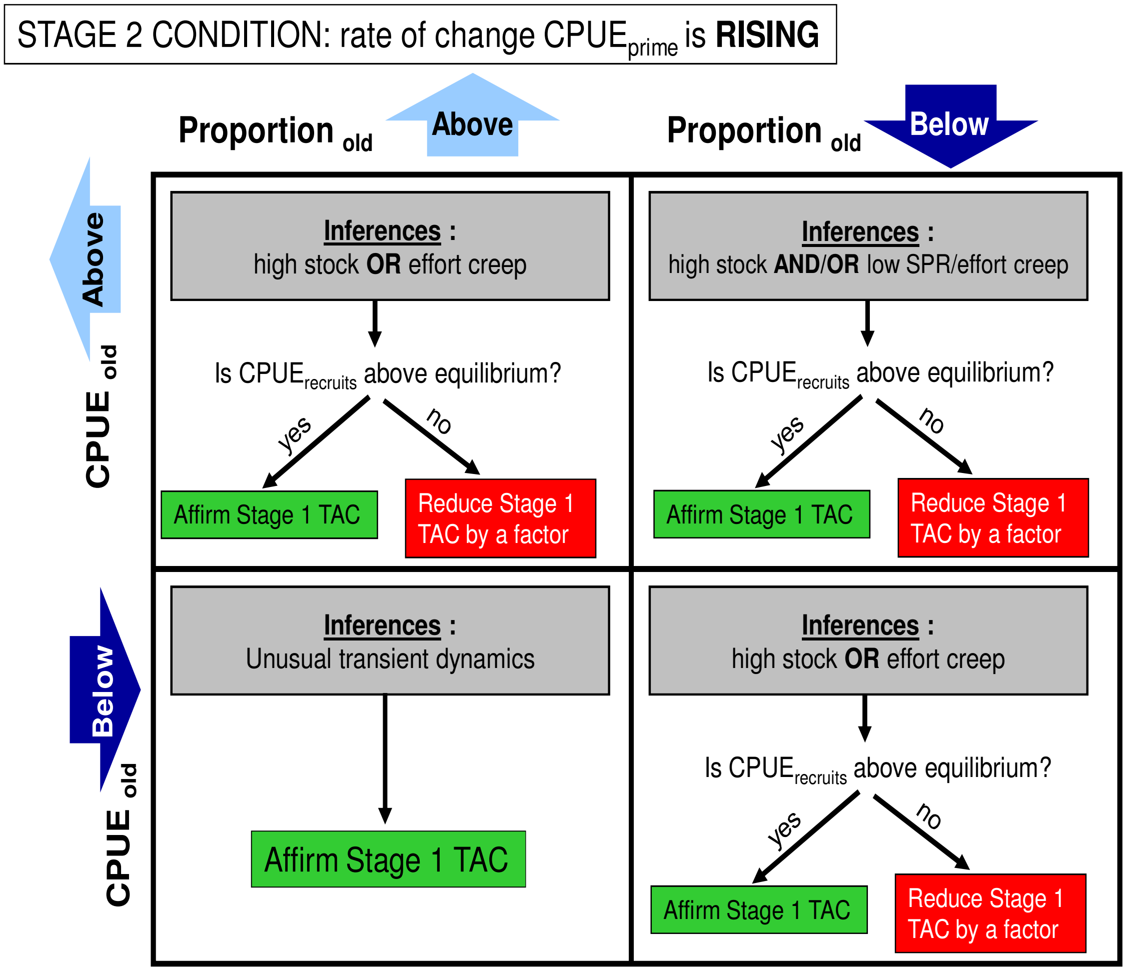
Step 4. Calculate CPUErecruits in the Catch and Compare to Target

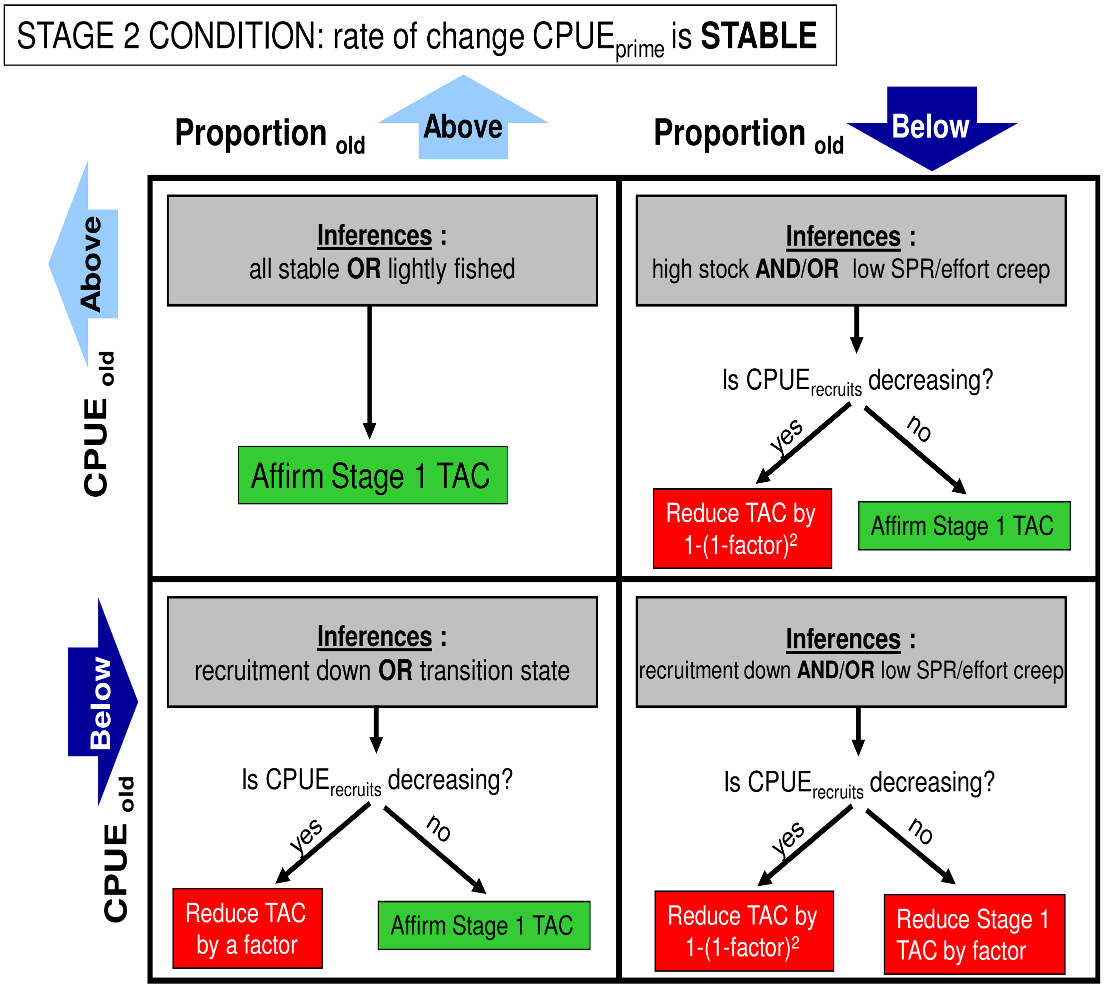
Calculate the current year CPUErecruits and compare to one of two target levels. The first target level is the CPUE recruits value that is calculated in the spreadsheet. The other CPUErecruit target is the average over the previous 5 years. Follow the flowchart below to determine which of the two CPUE recruit targets to use.

Step 5. Use Decision Tree to Adjust TAC

Follow the flow chart through each of the steps to determine the adjustment to the TAC in the following year:




STAGE 2 CONDITION: rate of change CPUE$_{prime}$ is RISING
Proportion $_{old}$
Above
Proportion $_{old}$
Below
CPUE $_{old}$
Above
CPUE $_{old}$
Below
Inferences :
high stock OR effort creep
Is CPUE$_{recruits}$ above equilibrium?
yes
no
Affirm Stage 1 TAC
Reduce Stage 1 TAC by a factor
Inferences :
high stock AND/OR low SPR/effort creep
Is CPUE$_{recruits}$ above equilibrium?
yes
no
Affirm Stage 1 TAC
Reduce Stage 1 TAC by a factor
Inferences :
Unusual transient dynamics
Affirm Stage 1 TAC
Inferences :
high stock OR effort creep
Is CPUE$_{recruits}$ above equilibrium?
yes
no
Affirm Stage 1 TAC
Reduce Stage 1 TAC by a factor



STAGE 2 CONDITION: rate of change CPUE$_{prime}$ is **STABLE**
Proportion $_{old}$
Above
Proportion $_{old}$
Below
CPUE $_{old}$
Above
CPUE $_{old}$
Below
Inferences :
all stable **OR** lightly fished
Affirm Stage 1 TAC
Inferences :
high stock **AND/OR** low SPR/effort creep
Is CPUE$_{recruits}$ decreasing?
yes
no
Reduce TAC by 1-(1-factor)^2
Affirm Stage 1 TAC
Inferences :
recruitment down **OR** transition state
Is CPUE$_{recruits}$ decreasing?
yes
no
Reduce TAC by a factor
Affirm Stage 1 TAC
Inferences :
recruitment down **AND/OR** low SPR/effort creep
Is CPUE$_{recruits}$ decreasing?
yes
no
Reduce TAC by 1-(1-factor)^2
Reduce Stage 1 TAC by factor

STAGE 2 CONDITION: rate of change $CPUE_{prime}$ is **FALLING**