Fisheries Performance Assessment Toolkit (FPAT)
6. Example FPAT Application

Benchmarking and Planning Effective Management

Presenter, Date 2022, Location

bluematter

Food and Agriculture Organization of the United Nations

UNIVERSITY of WASHINGTON

openMSE
www.openmse.com

Fishery Performance Indicators
www.fpilab.org

Contents

1. Requirements

To make our operating model (our fishery management calculator) we need:

- Natural mortality rate (natural survival)
- Somatic growth (how fast individuals fish grow and to what size)
- Maturity (length where 50% of fish are sexually mature)
- Fishery size selectivity (length at which fish are caught)
- Recruitment variability
- Historical pattern of exploitation (the historical pattern of fishing)
- Resilience (how fast the population recovers from low stock size)
- Stock status (spawning levels compared to ‘unfished’)

Sources

- Tariche 2002
- Tariche & Martins 2014
- Tariche et al. 2014

LIFE HISTORY AND STOCK ASSESSMENT OF THE AFRICAN HIND (*CEPHALOPHOLIS TAENIOPS*) (VALENCIENNES, 1828) IN SÃO VICENTE- SÃO NICOLAU INSULAR SHELF OF THE CAPE VERDE ARCHIPELAGO

Oksana Tariche Pastor
INDP - National Institute for Fisheries Development
Cape Verde

Tariche, O., & Martins, A. (2011). Dinamica populacional e availiacao do estado dos principais recuros halieuticos de Cabo Verde. Mindelo, Cabo Verde: Instituto Nacionale de Develvimento das Pescas (INDP).

Journal of the Marine Biological Association of the United Kingdom, 2015, 95(3), 599–609.
doi:10.1017/S0025315414001441

Age estimation and growth pattern of the grouper *Cephalopholis taeniops* (Epinephelidae) off the Cape Verde Archipelago, north-west Africa

O. TARICHE[1], J.G. PAJUELO[2], J.M. LORENZO[2], A. LUQUE[2] AND J.A. GONZALEZ[2]
[1]Instituto Nacional de Desenvolvimento das Pescas, C.P. 132, Mindelo, São Vicente, Cape Verde, [2]Departamento de Biología Universidad de Las Palmas de Gran Canaria, Campus de Tafira, Las Palmas de Gran Canaria, 35017 Las Palmas, Spain

The grouper Cephalopholis taeniops *is a carnivorous fish of the Cape Verde coastal marine ecosystem. Nothing is known regarding the age and growth of this epinephelid. In this study, the age and growth of* C. taeniops *was investigated by annual growth increment counts from 2804 specimens (7–51 cm total length) collected between January 2005 and*

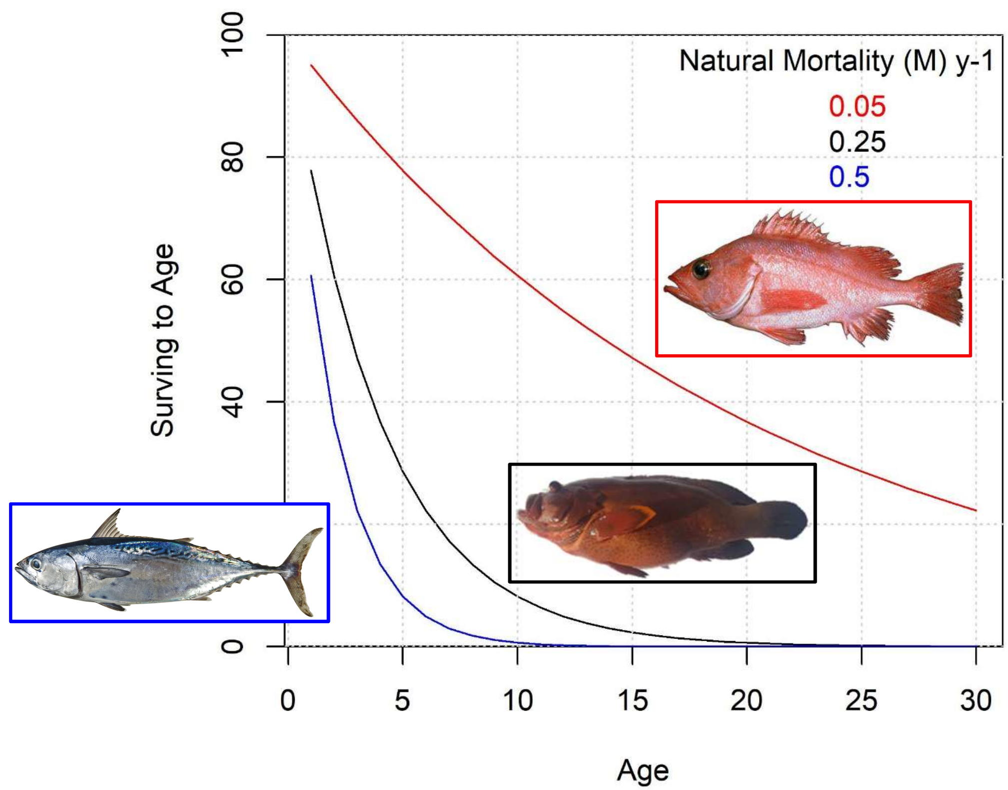
2. Fishery Data Sheet

Natural Mortality Rate (M)

A very important characteristic of population dynamics.

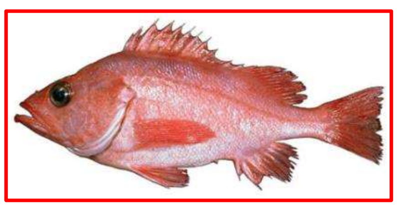
Controls how many cohorts (age classes) are in the population and hence:

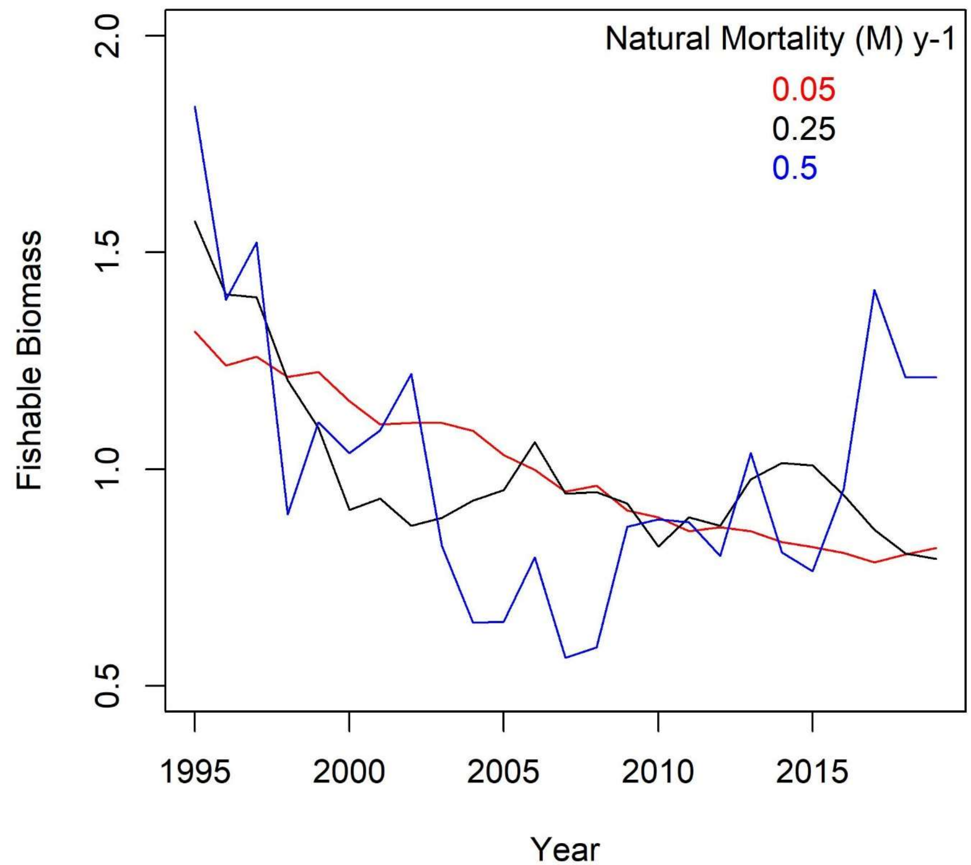
- The naturally variability of the population
- What fraction of the population can be caught sustainably and productively.



Impact of natural mortality rate (M) on biomass variability

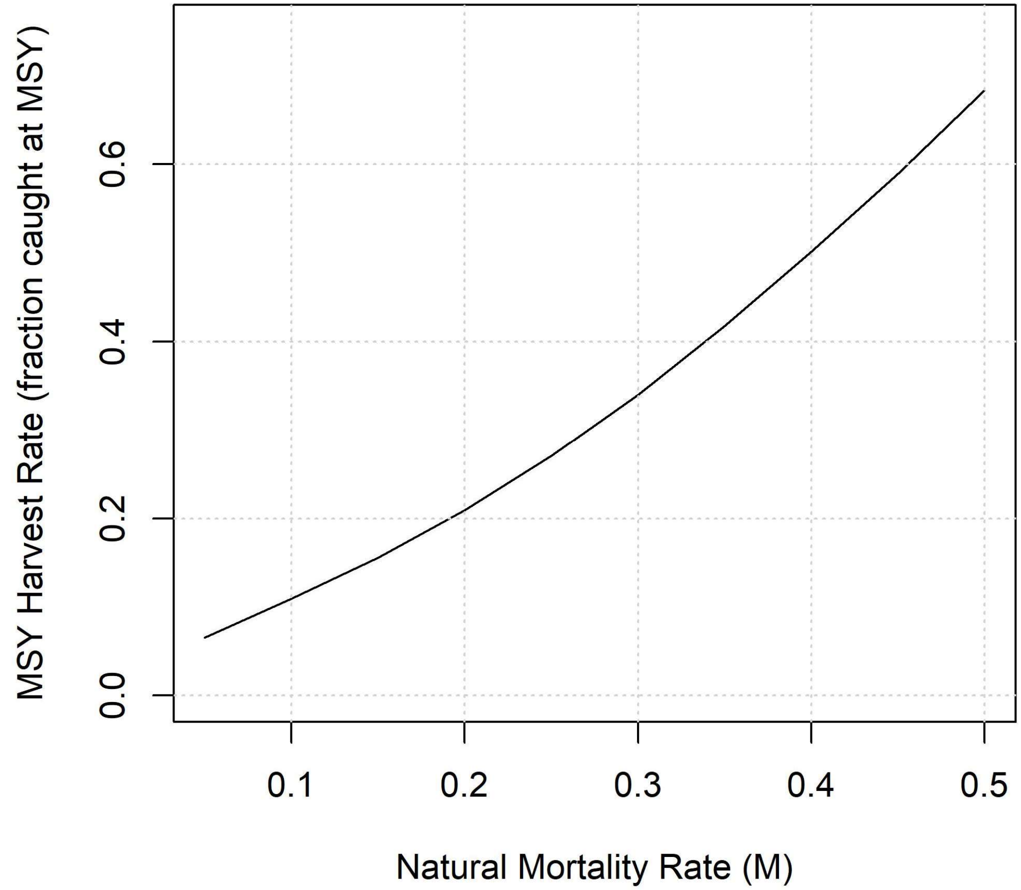
All things being equal, longer-living fish have a larger number of cohorts (age classes) and so recruitment variability has less impact on biomass.





Impact of natural mortality rate (M) on productive sustainable harvest rate

All things being equal, populations of longer-living fish can withstand lower productive exploitation rates – the fraction of fish that can be taken is lower.



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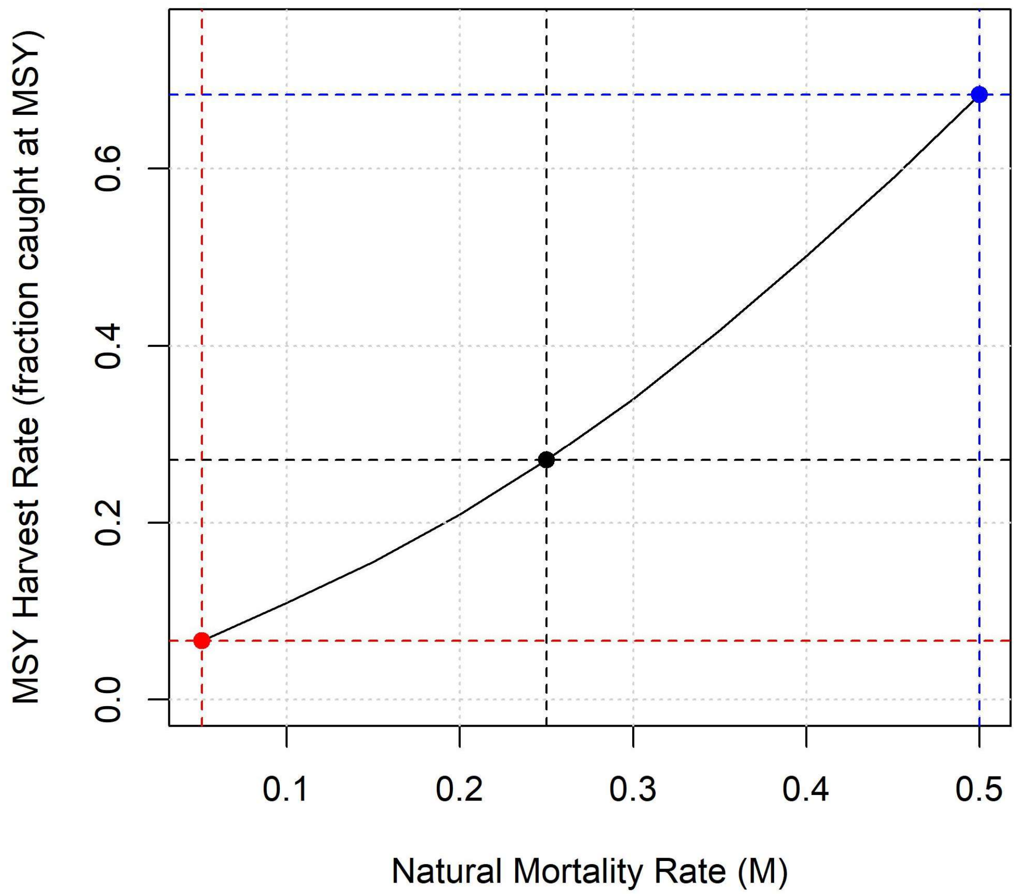

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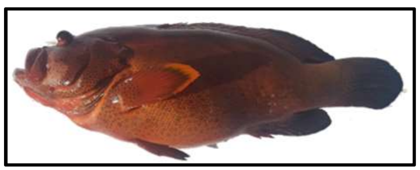
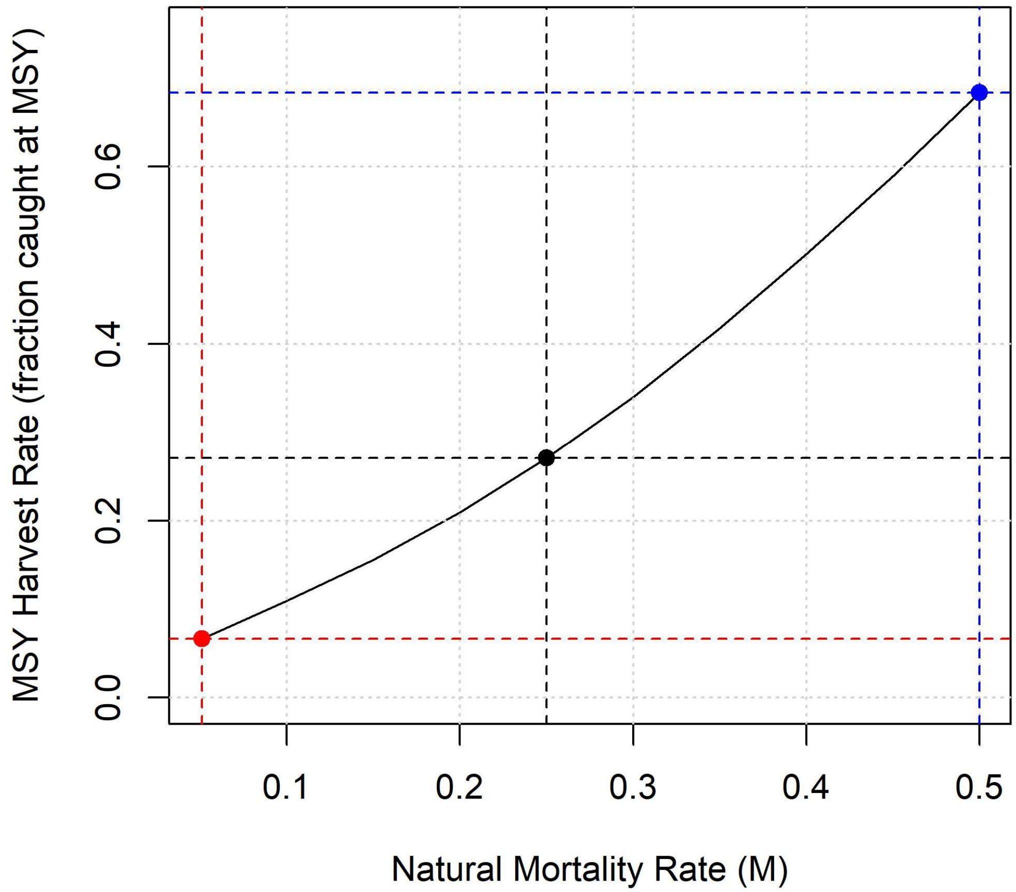
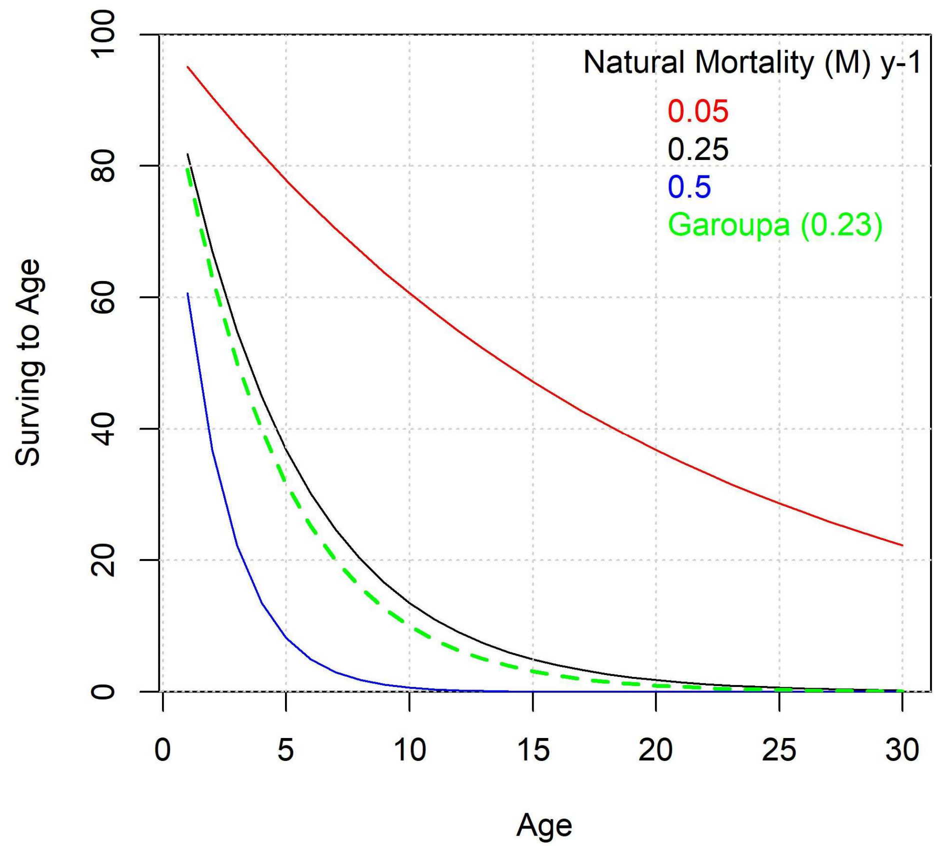




Natural Mortality Rate

- Tariche 2002 used maximum age approach and test 0.25, **0.38**, 0.51
- " At the same time, the initial estimate of M [0.38] seems to be too high, probably due to the restricted range of age groups on which estimation is based. For those reasons, estimations based on M=0.25 seem to be more reasonable"
- At a 1% survival rate to age 20, $M = 0.23 = -\ln(0.01)/20$
- Here we assume $M = 0.23$

Natural Mortality Rate (M)



Somatic growth

	A	B
16	Von Bertalanffy Linf parameter	54.26
18	Von Bertalanffy K parameter	0.135
20	Von Bertalanffy t0 parameter	-0.853

... 13. Fishery Data | 8. Output-graph by TBL | 9. Output-gra

Controls:

- the natural speed of population growth (biomass growth)
- the impact of fishery size selectivity. The naturally variability of the population

Somatic growth

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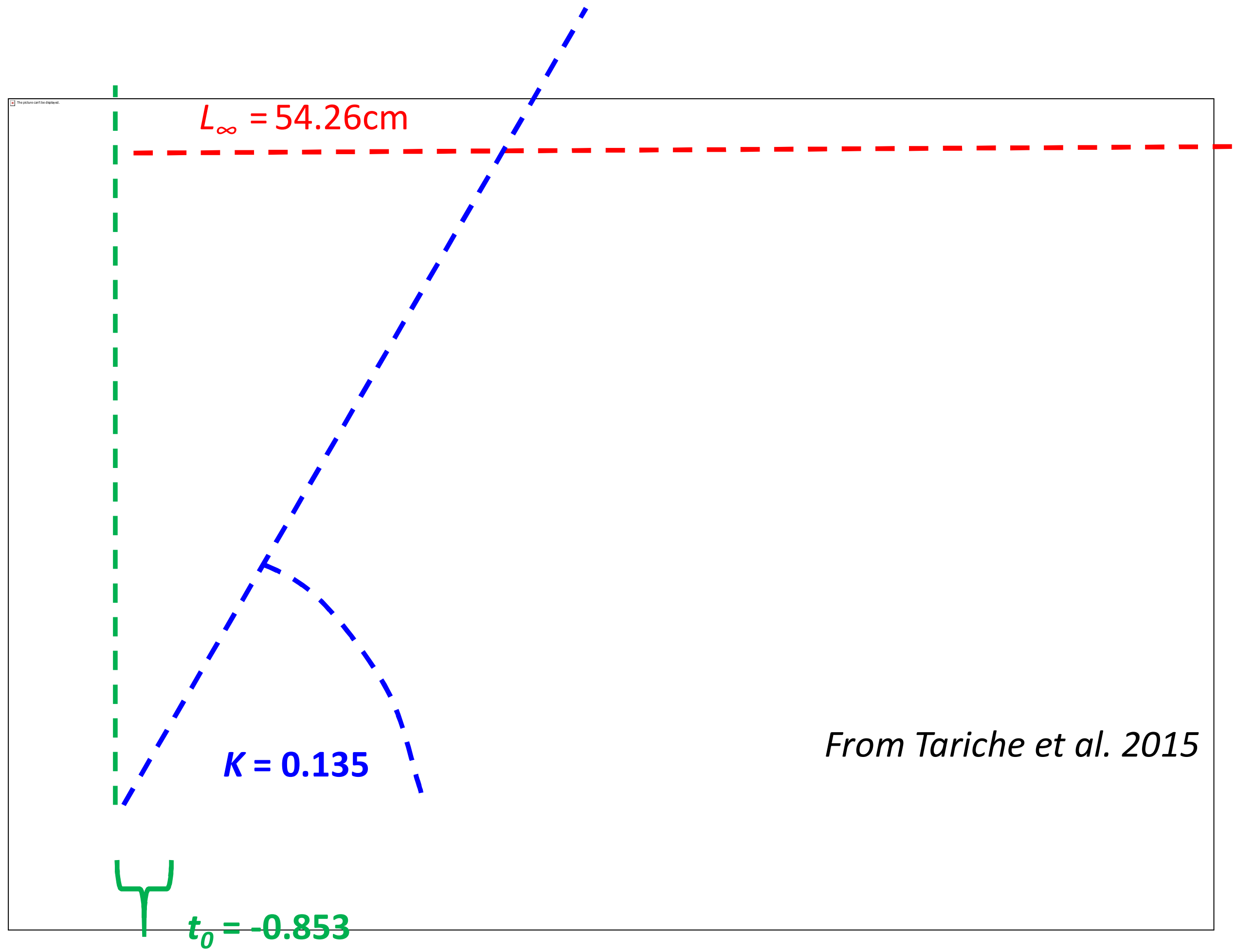
From Tariche et al. 2015

Somatic growth

Three parameters:

- Asymptotic size (L_∞ ,'L-infinity)
- Maximum growth rate (K, L_∞ yr^{-1})
- Age at length zero (t_0)



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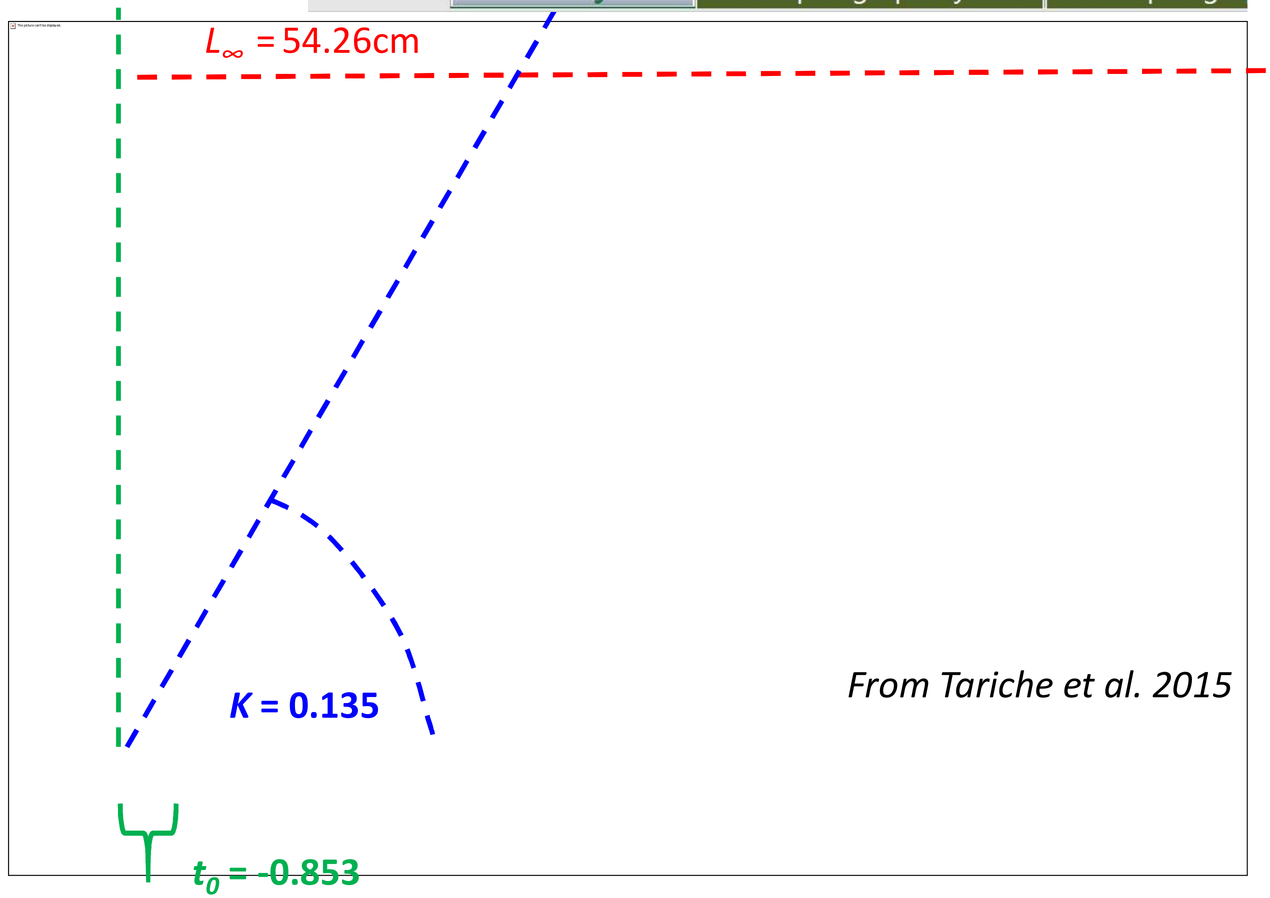


From Tariche et al. 2015

Somatic growth

	A	B
22	Length-weight parameter a	0.0000067
24	Length-weight parameter b	3.2384

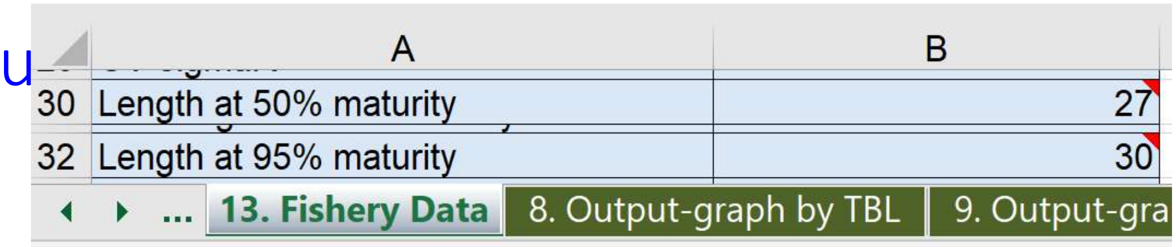
13. Fishery Data | 8. Output-graph by TBL | 9. Output-gra

Scales numbers to weight so controls the scale of the fishery inferred by the data.

Here the a parameter is fitted in grams and must be divided by 1000 to provide weight in the same units as observed catches (kg)

From Tariche 2002

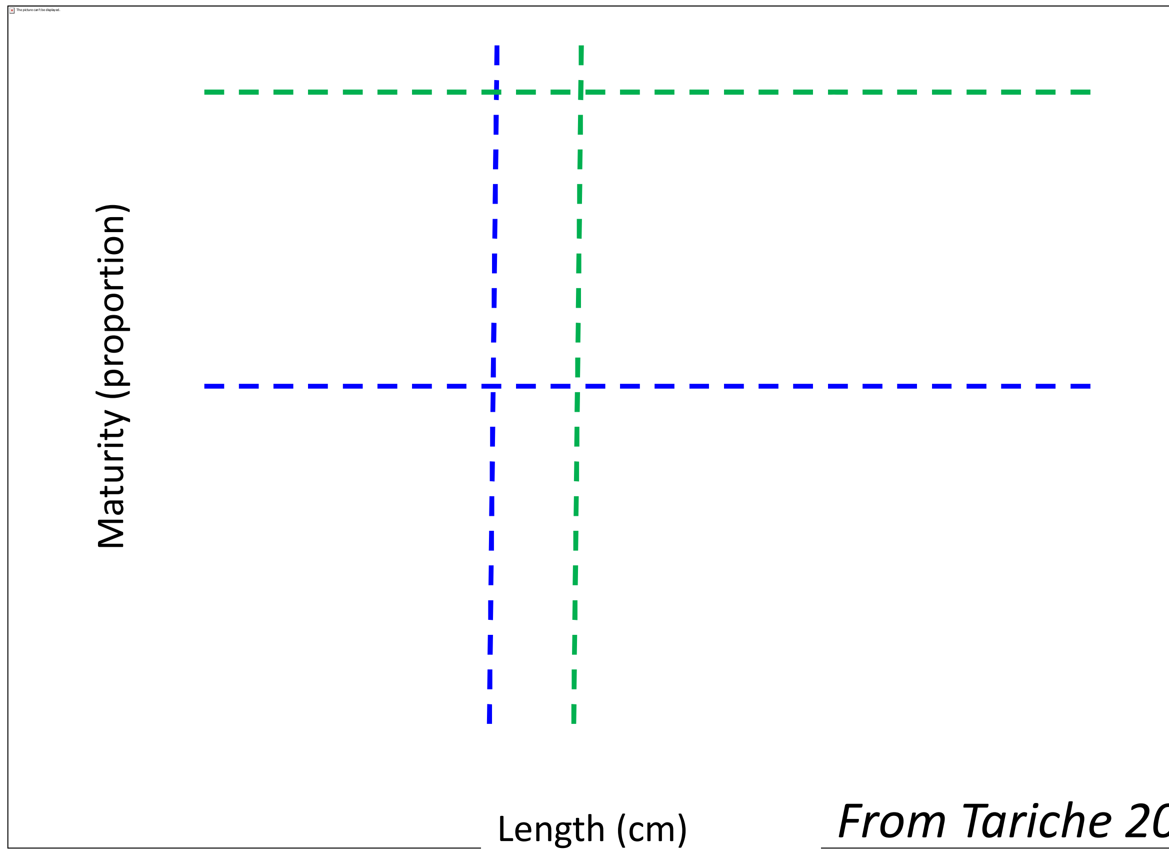
Maturity (proportion matu… at length)



	A	B
30	Length at 50% maturity	27
32	Length at 95% maturity	30

Length at 50% maturity = 27cm

Length at 95% maturity = 30cm



From Tariche 2002

Requirements

To make our operating model (our fishery management calculator) we need:

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- Recruitment variability
- Historical pattern of exploitation (the historical pattern of fishing)
- Resilience (steepness, how fast the population recovers from low stock size)
- Stock status (spawning levels compared to ‘unfished’)

1. Requirements

All of the remaining aspects would ideally be estimated from data by conditioning an operating model (essentially a stock assessment):

- Fishery size selectivity (length at which fish are caught)
- Recruitment variability
- Historical pattern of exploitation (the historical pattern of fishing)
- Resilience (steepness, how fast the population recovers from low stock size)
- Stock status (spawning levels compared to ‘unfished’)

Operating model conditioning can make use of a wide range of data but *requires*:

- Time series of annual catches

  Or

- Complete time series of annual effort (for scale free model)

And

- Relative abundance index observations (can be patchy) that cover a suitably wide time-range

  Or

- Patchy length (or age) composition data, preferably available for at least one recent year.

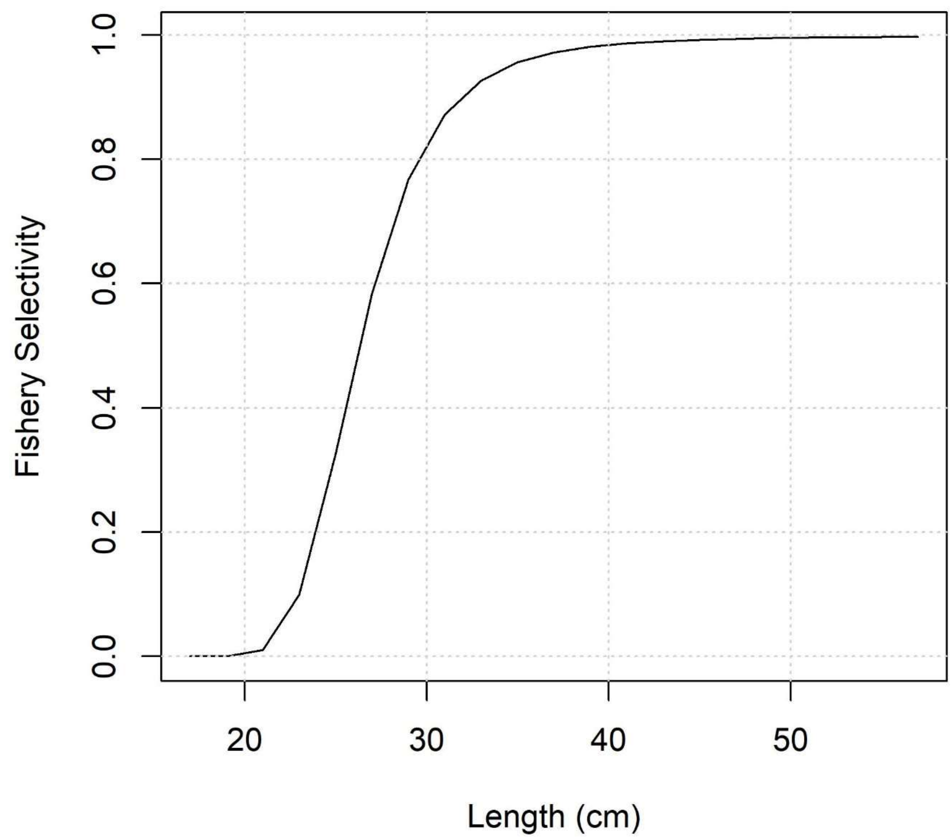
- Fishery size selectivity (length at which fish are caught)
- Recruitment variability
- Historical pattern of exploitation (the historical pattern of fishing)
- Resilience (steepness, how fast the population recovers from low stock size)
- Stock status (spawning levels compared to ‘unfished’)

Fishery Selectivity

* Best that this is estimated by a stock assessment.

	A	B
36	Length at first capture	22
38	Length at full selection	35
40	Vulnerability at asymptotic length	1

13. Fishery Data | 8. Output-graph by TBL | 9. Output-grap



Fishery Selectivity

* Best that this is estimated by a stock assessment.

Length at first (5%) capture

Length at full selection

Vulnerability at asymptotic length

	A	B
36	Length at first capture	22
38	Length at full selection	35
40	Vulnerability at asymptotic length	1

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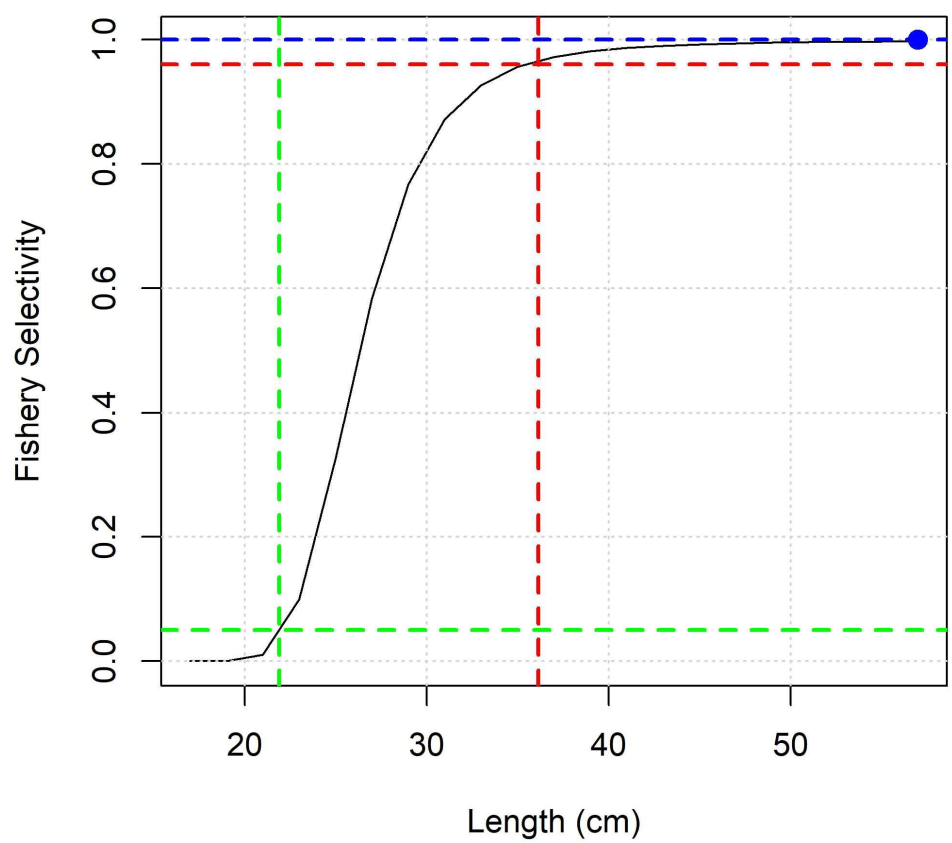


Fishery Selectivity

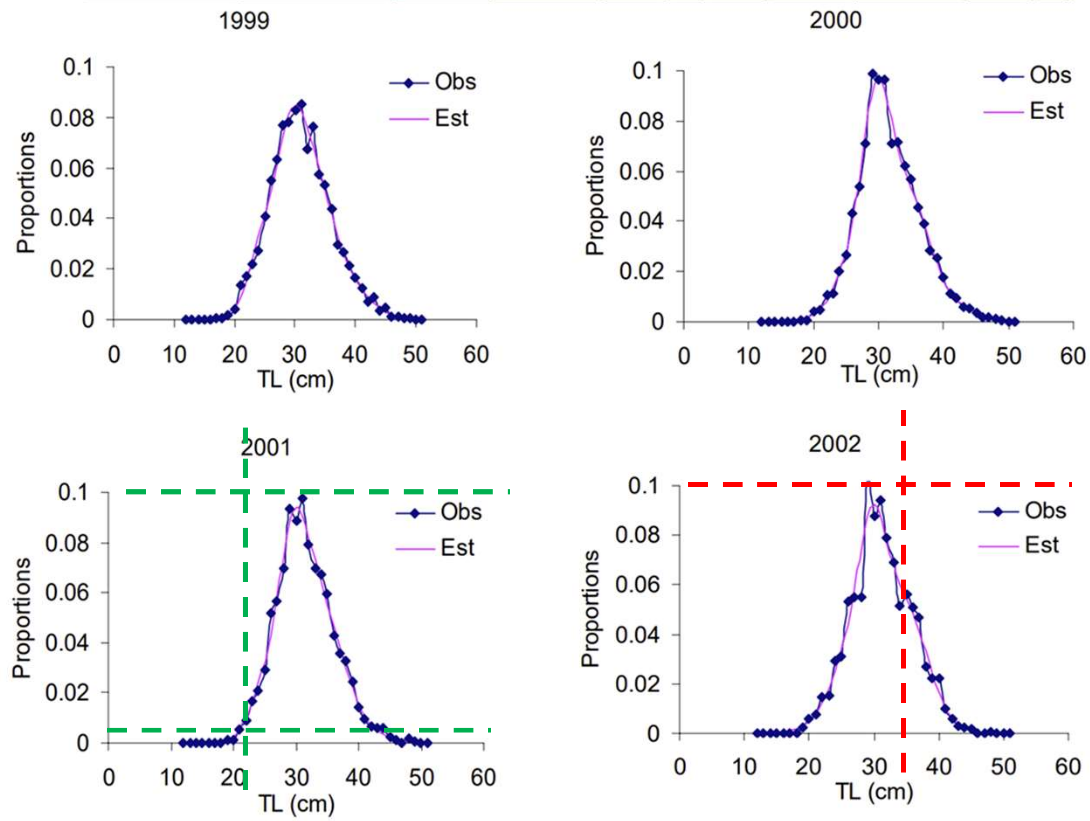
Best to be estimated in a stock assessment.

Length at first (5%) capture is relatively straightforward. ~22cm

Length at full selection (95%) is harder to eyeball and occurs at lengths longer than those of the mode (~35cm)

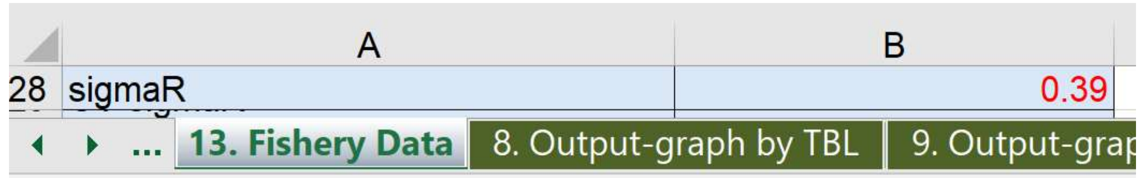
	A	B
36	Length at first capture	22
38	Length at full selection	35
40	Vulnerability at asymptotic length	1

... 13. Fishery Data | 8. Output-graph by TBL | 9. Output-grap



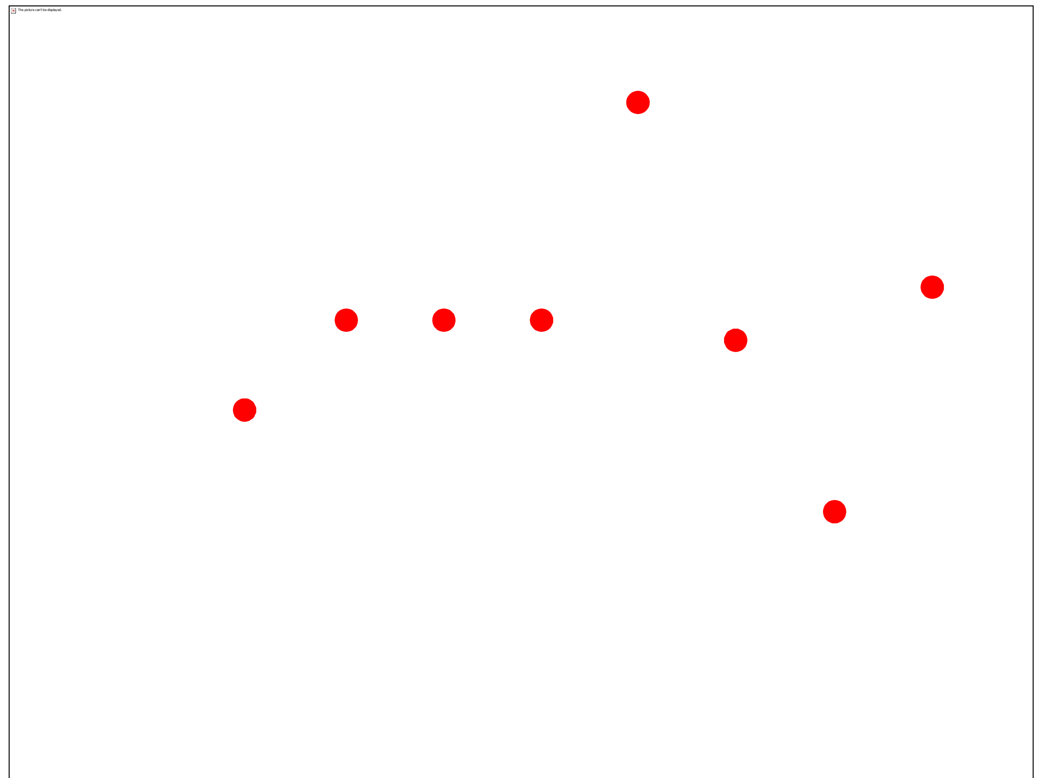
From Tariche 2002

Recruitment Variability



* Best that this is estimated by a stock assessment.

Sigma R = standard deviation of log(R)
= 0.39



From VPA assessment of Tariche 2002

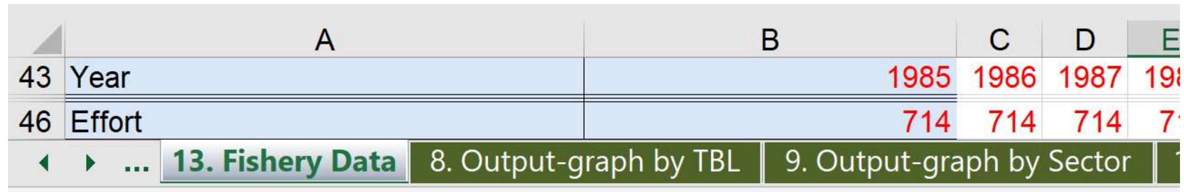
Historical Pattern of Exploitation

* Best that this is estimated by a stock assessment.

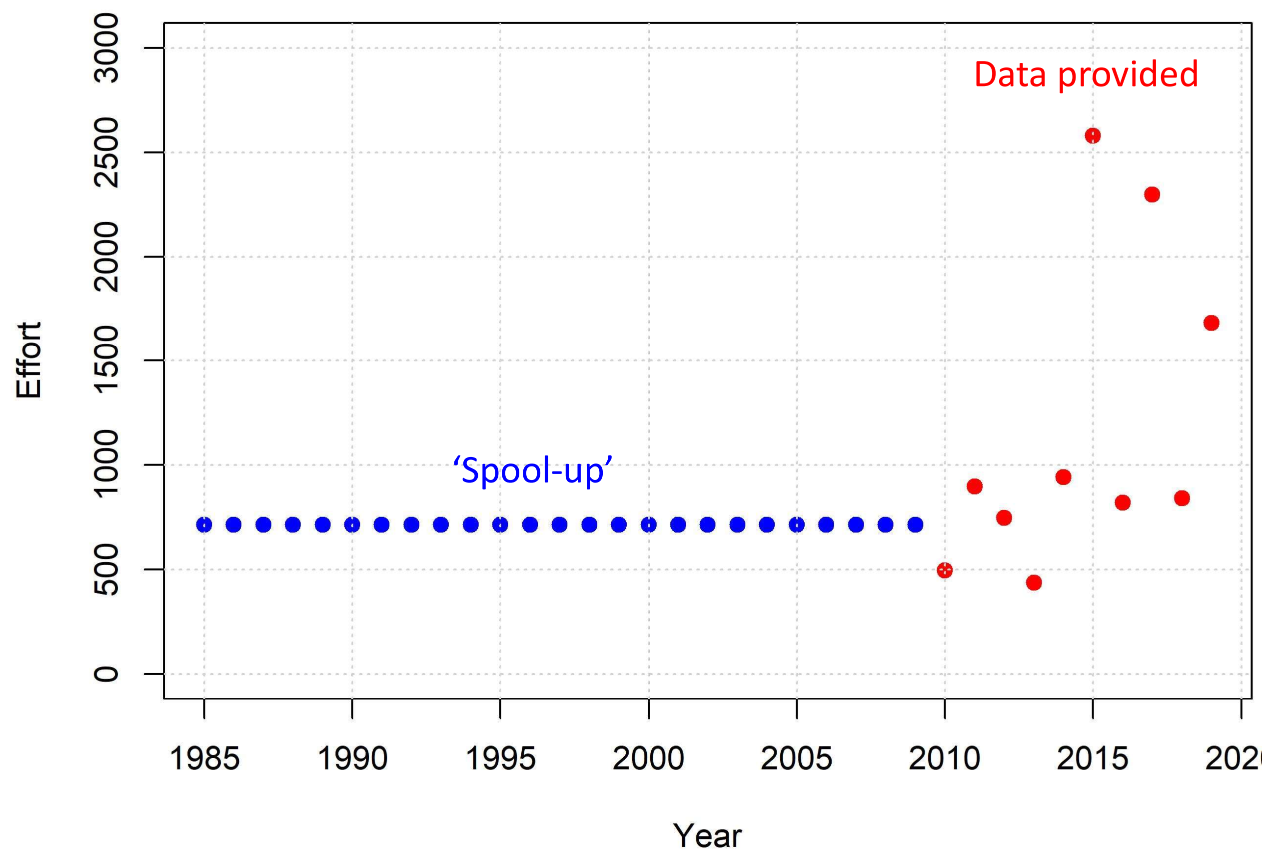
A measure of fishing pressure (e.g., days of fishing, trap-days), often assumed to be proportional (or positively related) to fishery exploitation rate.

In the FPAT app the pattern of fishery exploitation coupled with the estimate of current stock depletion (stock status, spawning biomass relative to 'unfished'), is required to reconstruct the historical population and fishery data.

Outside of the app, these data can be used in OM conditioning, and the OM brought into the FPAT app.

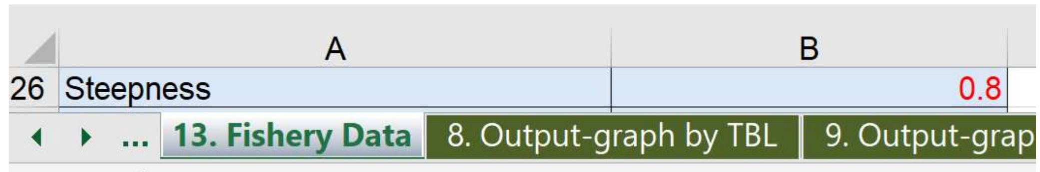


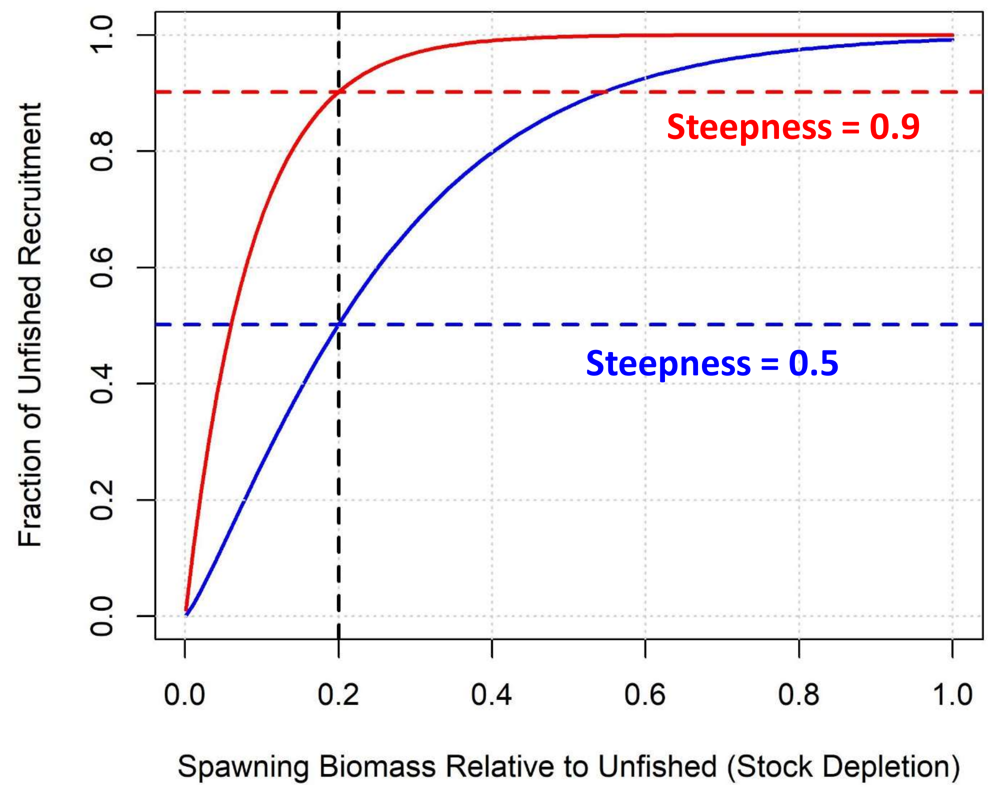
	A	B	C	D	E
43	Year	1985	1986	1987	198
46	Effort	714	714	714	71



Resilience

* Best that this is estimated by a stock assessment.





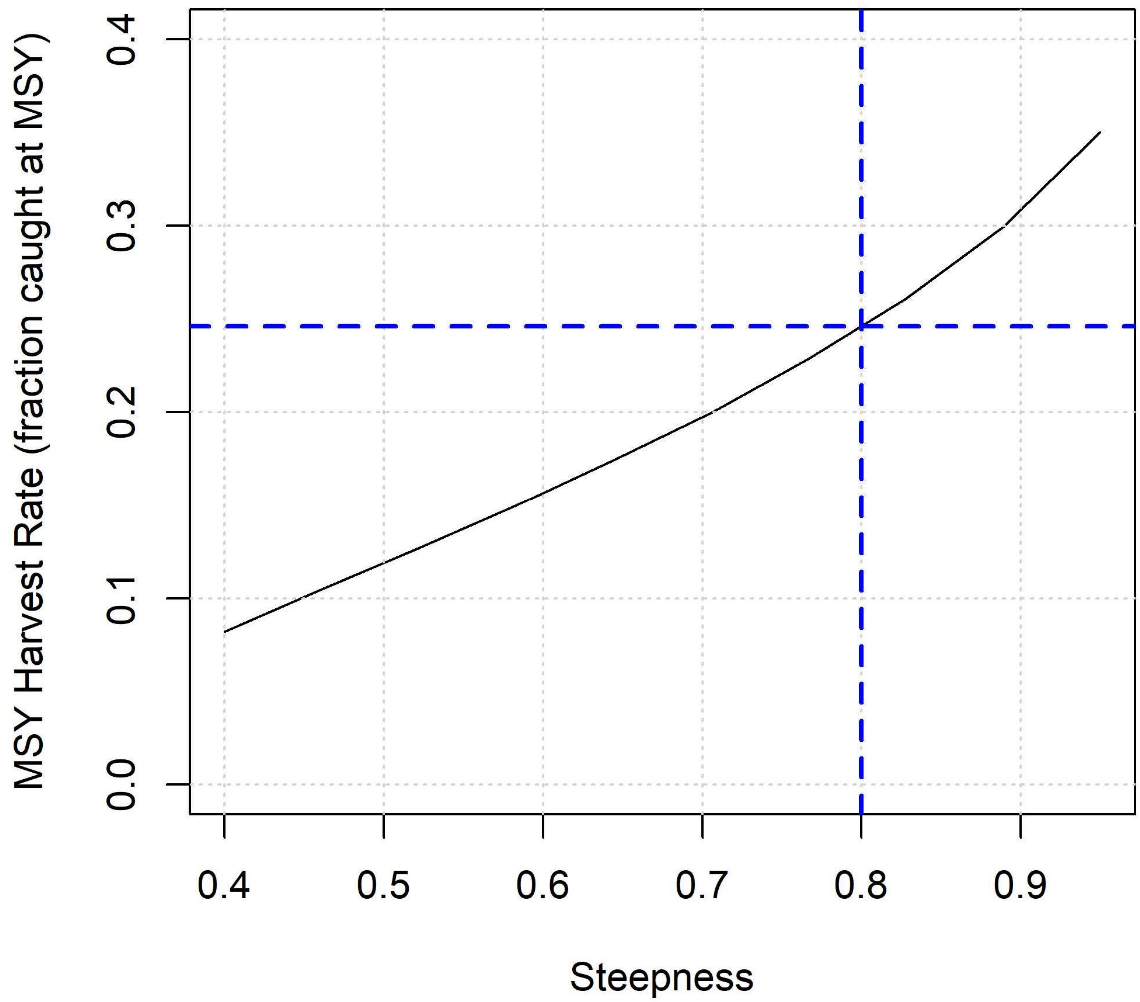
Often measured by 'steepness' (the fraction of unfished recruitment at 20% of unfished spawning biomass), resilience determines how productive a stock is as spawning biomass declines.

The only grouper-like species I could find an age structured assessment for that could estimate steepness was Red Grouper in the Gulf of Mexico (NOAA SAR 12) that estimated steepness = 0.84.

Dissimilar species and ecology however.

Resilience

All things being equal, steepness is a strong determinant (although maybe not as strong as M) of the harvest rate at MSY (the highest sustainable harvest).



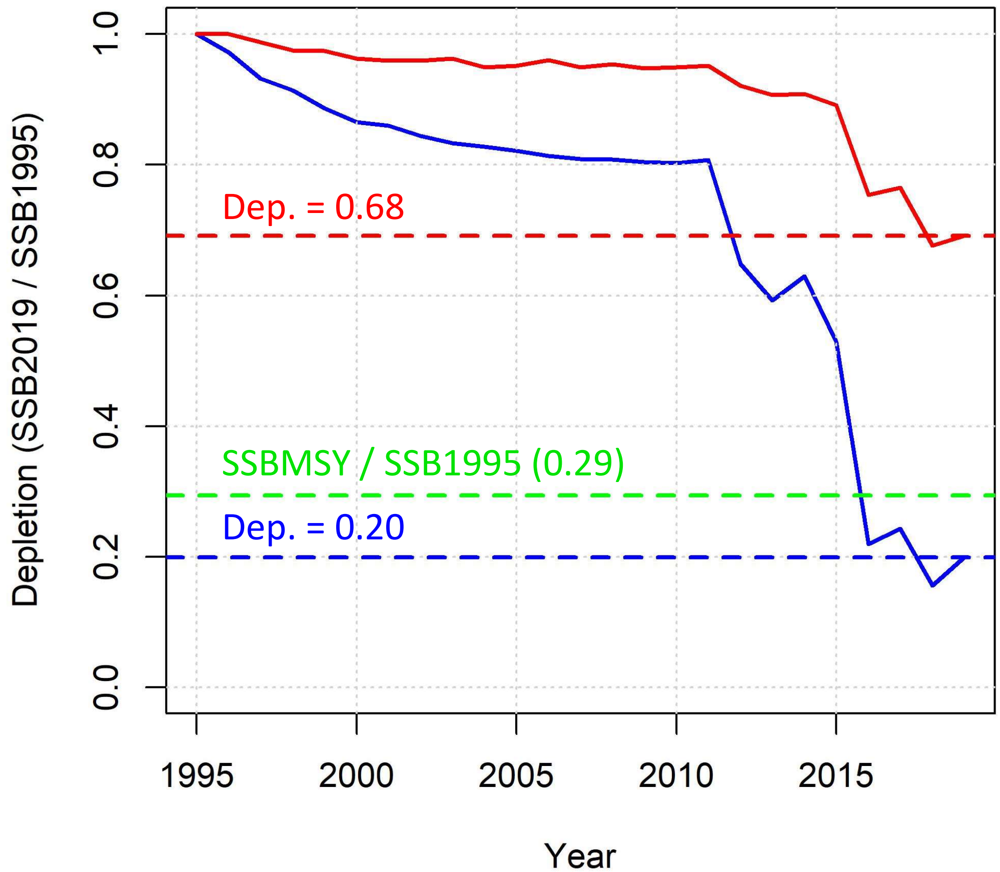
Stock Depletion

* Almost always estimated by a stock assessment.

Normally phrased as Spawning Stock Biomass (SSB) relative to unfished levels

	A	B
72	Reference	
73	Current stock depletion	0.50
74	CV current stock depletion	0.30

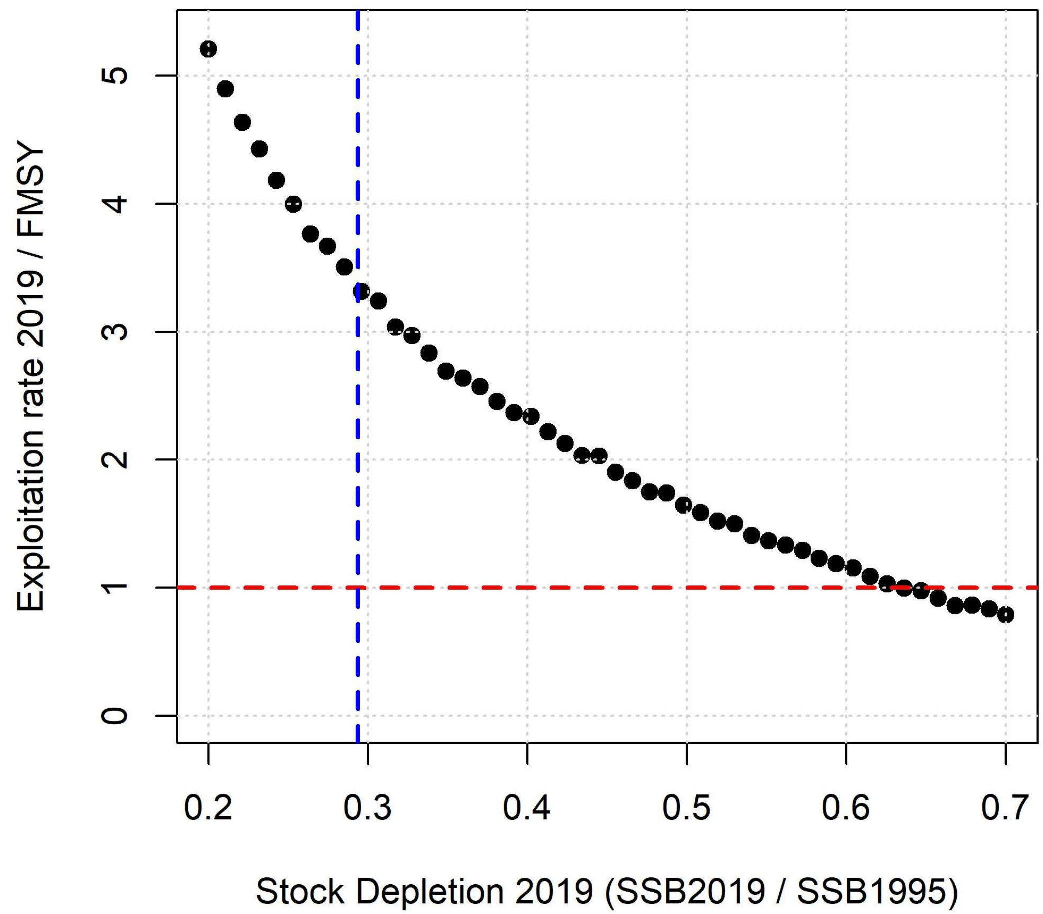
13. Fishery Data | 8. Output-graph by TBL | 9. Output-graph



Stock Depletion

* Almost always estimated by a stock assessment.

All things being equal (and with low recruitment variability), specified depletion below 60% requires high fishing mortality rates (above FMSY, so overfishing) given the short time period of assumed exploitation (1995 – 2019 in this demonstration).



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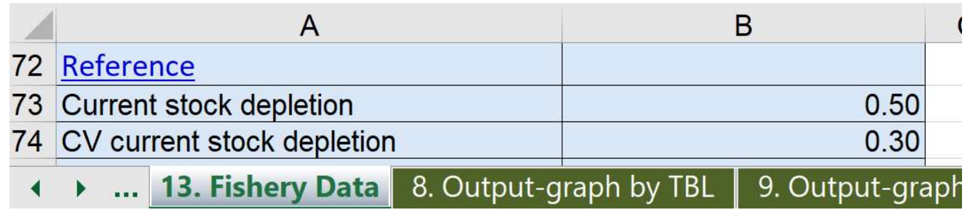

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72	Reference	
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* Almost always estimated by a stock assessment.

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Dep. = 0.68

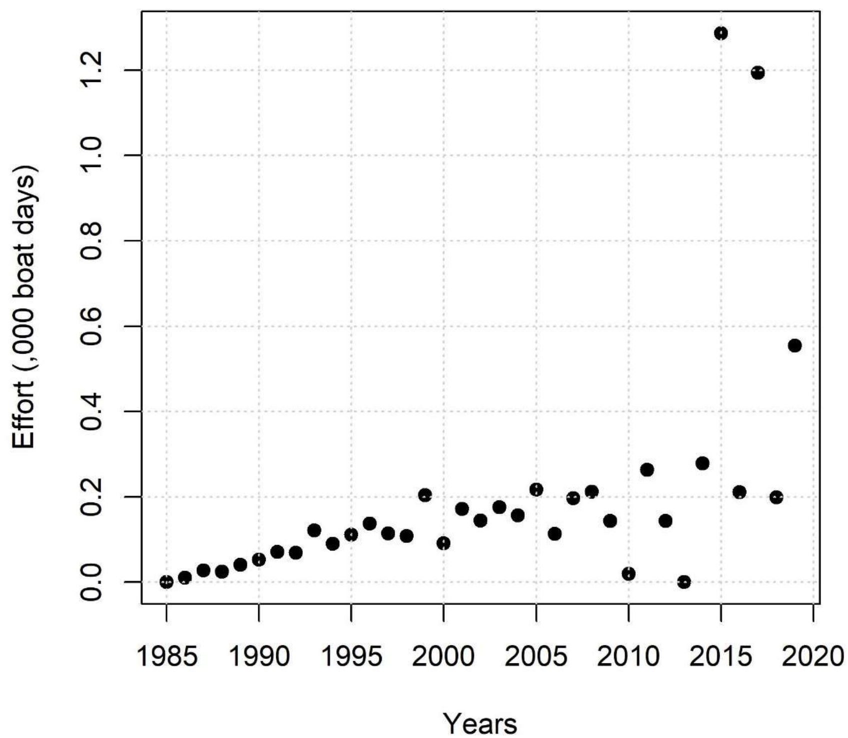
SSBMSY / SSB1995 (0.29)

Dep. = 0.20

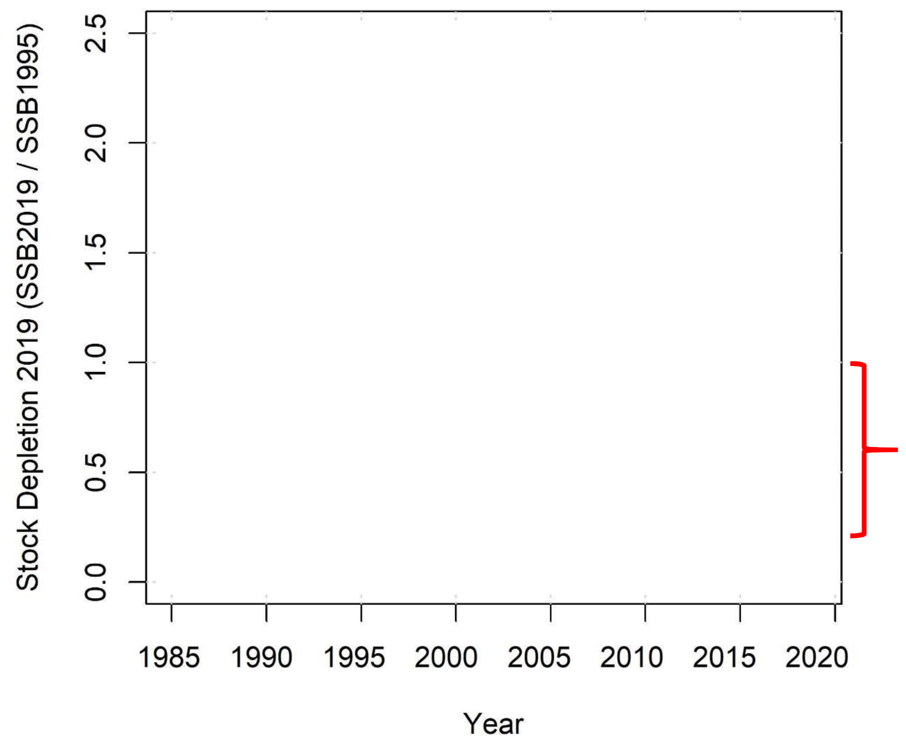
4. Time Series Data

In its simplest form, the App reconstructs the historical fishery using a history of Effort and specified stock depletion:

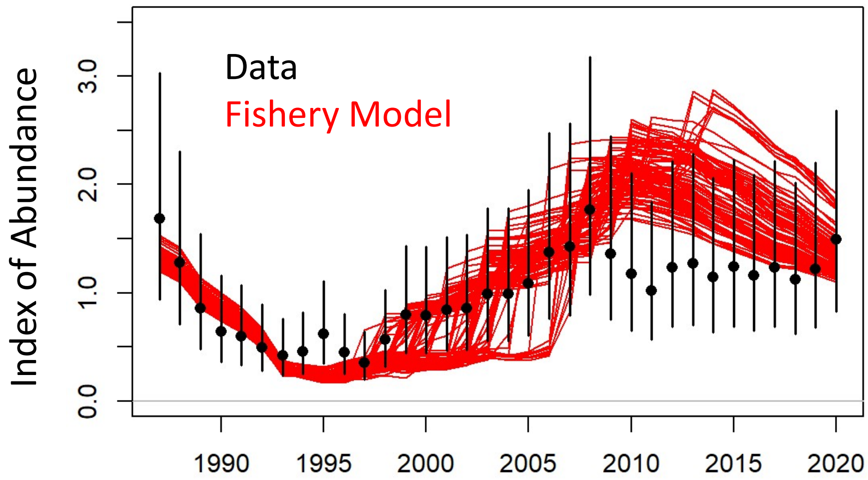
Complete Effort Since Start of Fishery



Specified stock depletion. Spawning biomass in last year (2020) relative to first year (1985)



Model fitting



It is preferable to fit models to data:

- Ensures empirical credibility (that the model fits our observations)
- Stock status is *estimated* not an input
- Characterizes uncertainty in population & fishery
- Greater objectivity (relies less on expert judgement)
- Ensures data are simulated properly (we test management options with more realistic quality of data)

Fitting FPAT models requires:

Somatic growth, length-weight, maturity at length.

AND

Time series of annual catches

Or

Complete time series of annual effort (for scale-free model)

AND

Relative abundance index observations (can be patchy) that cover a suitably wide time-range.

Or

Patchy length (or age) composition data, preferably available for at least one recent year.

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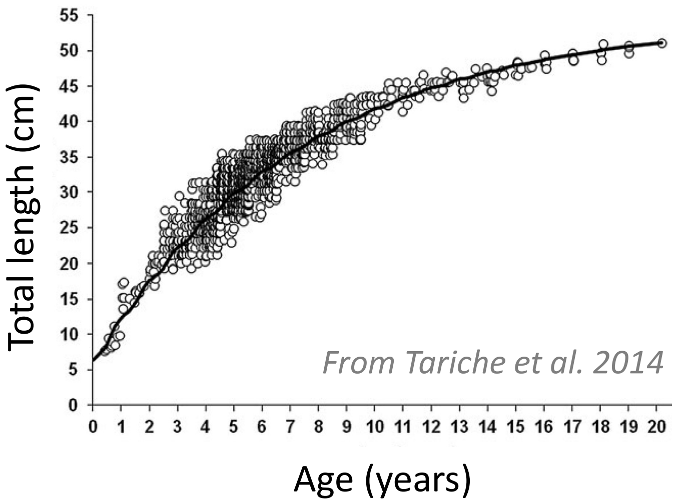

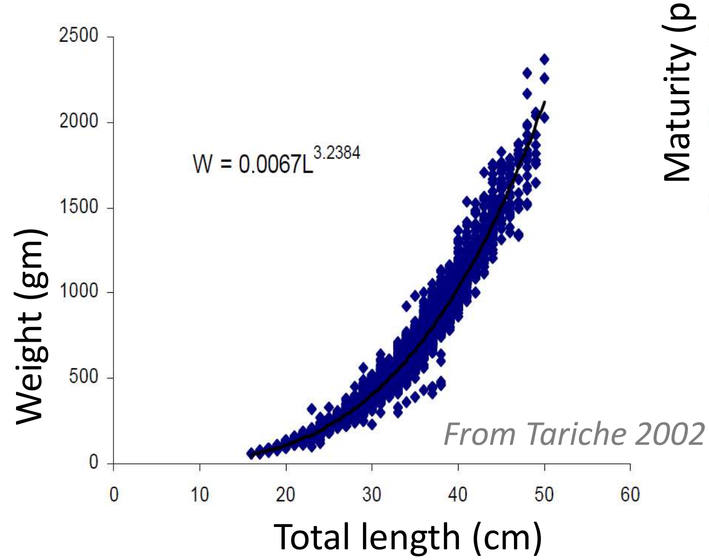

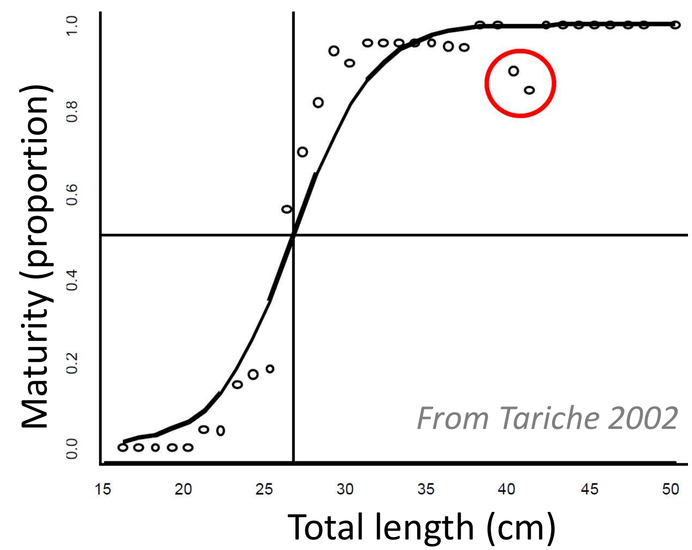

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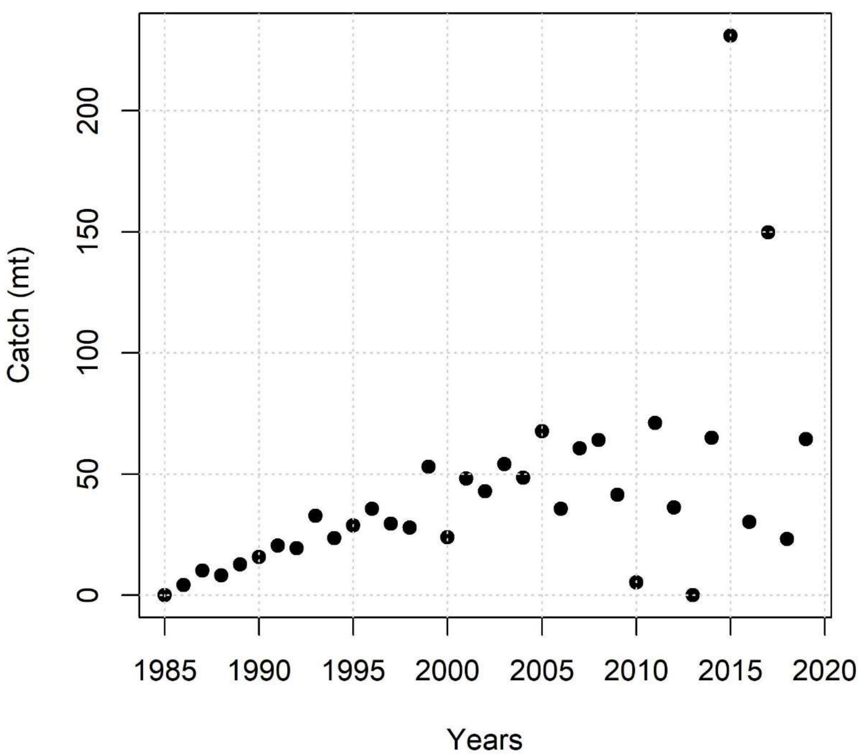
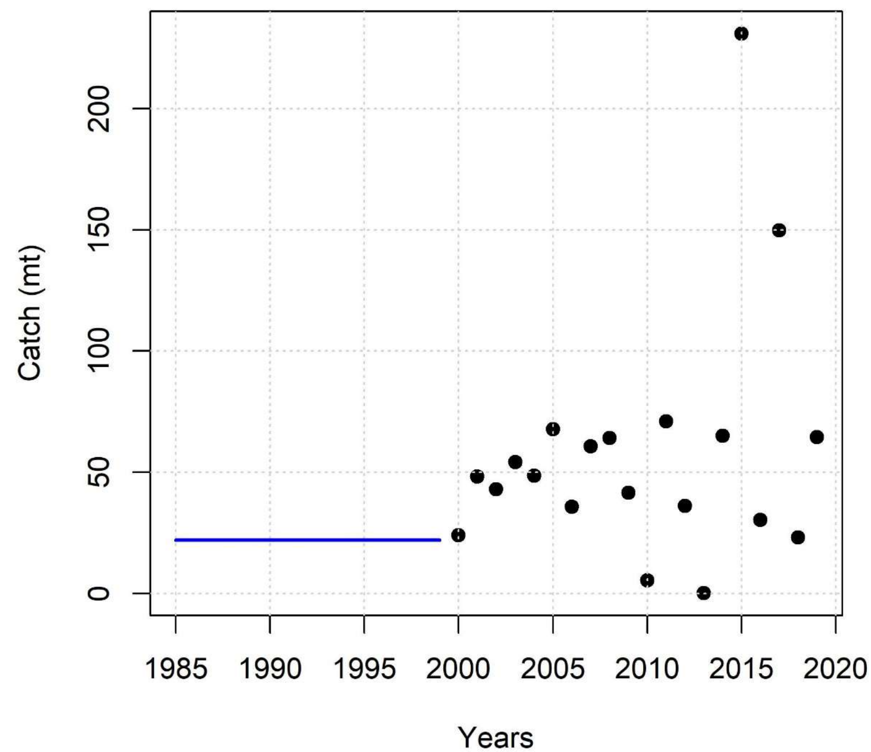
Annual Catch Data

Complete Catches Since Fishery Inception



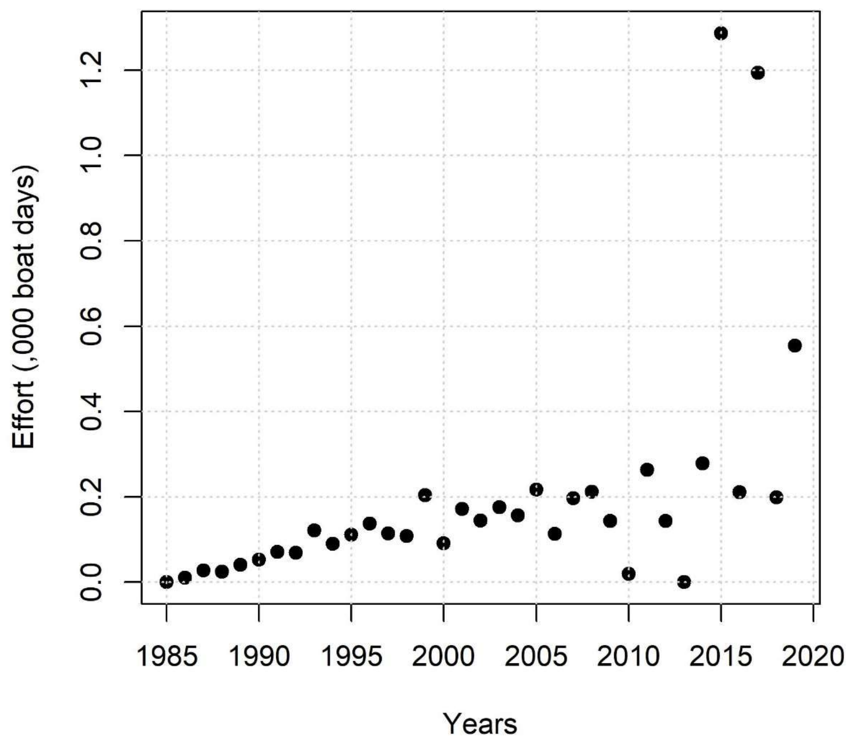
Recent catches with ‘spool-up’ mean catches prior to time series



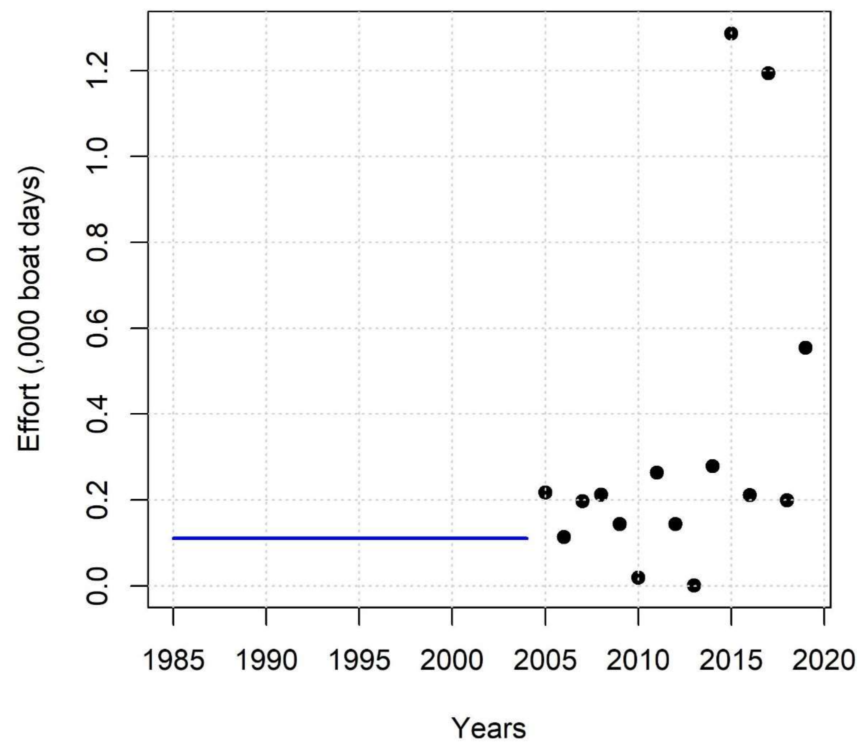
Annual Fishing Effort Data

A measure of overall fishing pressure. E.g., boat-days, trap-hours etc.

Complete Effort Since Fishery Inception



Recent effort with 'spool-up' mean effort prior to time series



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Relative abundance index observations (can be patchy) that cover a suitably wide time-range.

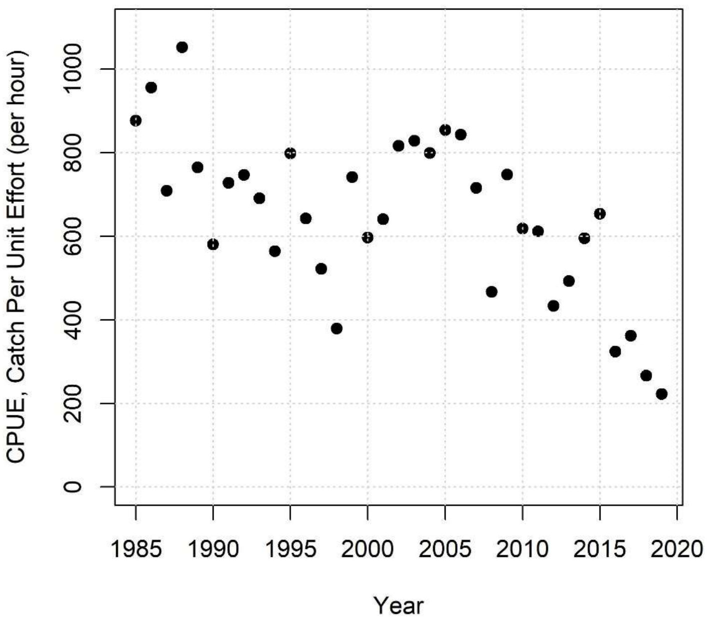
Or

Patchy length (or age) composition data, preferably available for at least one recent year.

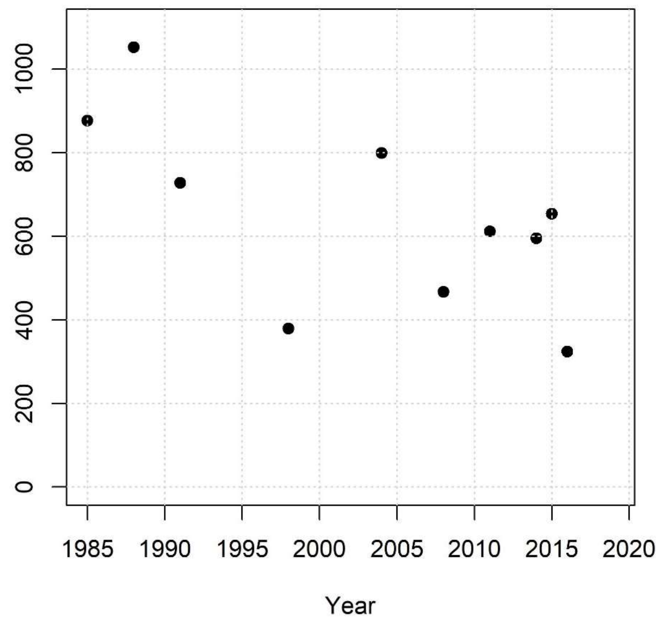
Relative abundance index data

- Can be catch-per-unit-effort (e.g. fish per hour, fish per day)
- Have catch rates declined?

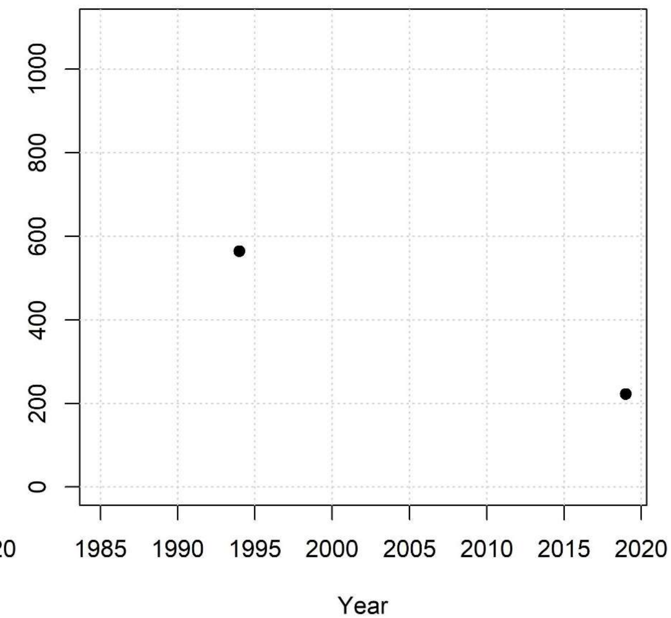
Complete Abundance Index



Incomplete Abundance Index (spanning a reasonably long time interval)

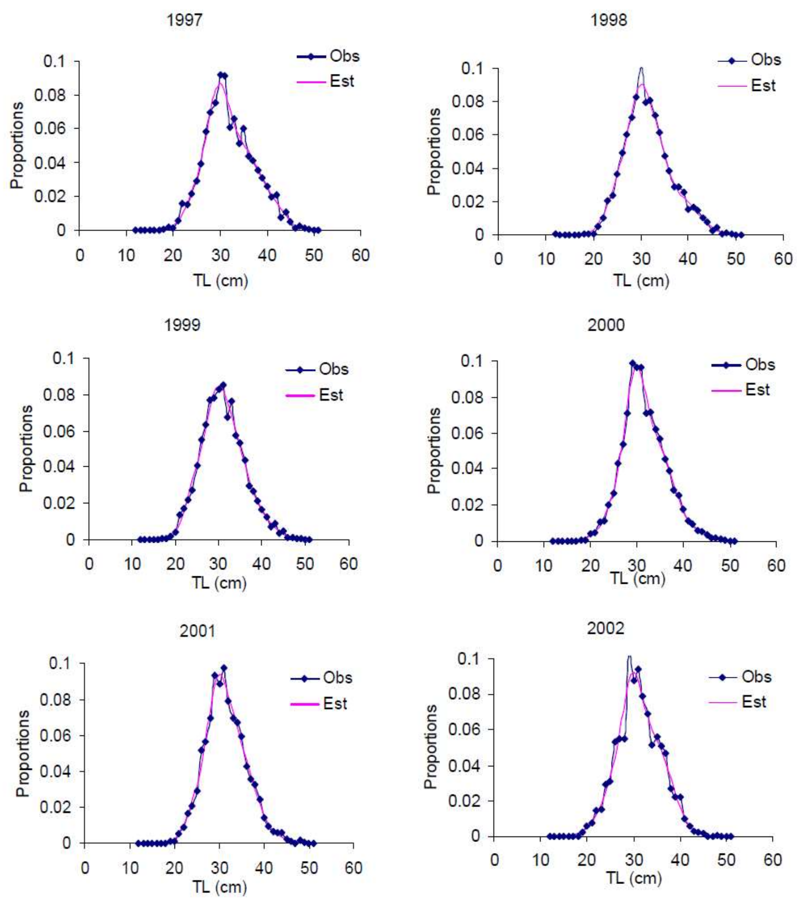


Just two observations (spanning a reasonably long time interval)



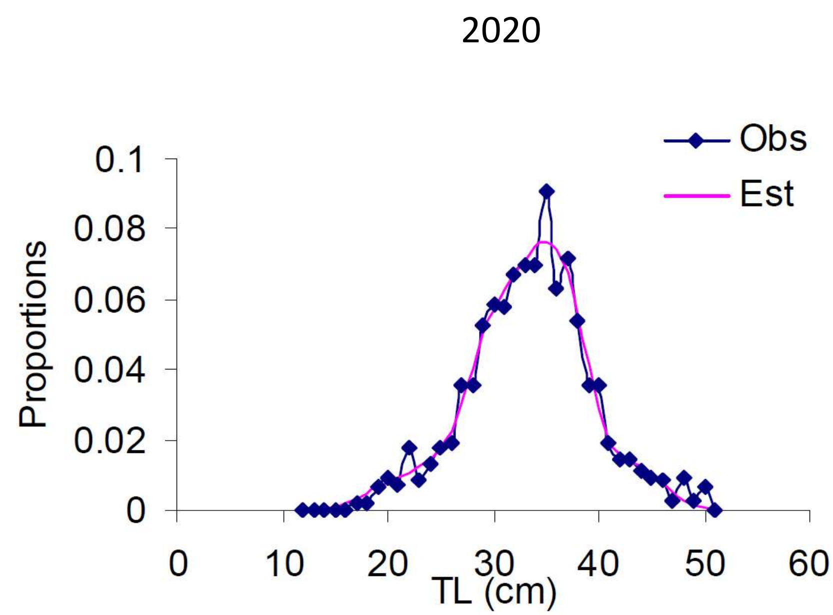
Catch length composition data

Many years



From Tariche 2002

A recent year



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Or

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Excel format circulated by email

Example data sheet.xlsx

Field	Value
Name	Data Grouper
Common Name	Garoupa
Species	*Chephalopholis taeniops*
Region	Sao Vicente
Last Historical Year	2021
Previous TAC	
Units	kg
Previous TAE	
nareas	
Biology	
Maximum age	20
M	0.23
CV M	
Von Bertalanffy Linf parameter	54.26
CV von B. Linf parameter	
Von Bertalanffy K parameter	0.135
CV von B. K parameter	
Von Bertalanffy t0 parameter	-0.853
CV von B. t0 parameter	

5. Summary

In this example Garoupa has reasonable inputs except:

1. Historical effort pattern
2. Steepness (red grouper in Gulf of Mexico is a stretch)
3. Stock depletion

Could be solved my obtaining fishery data and conditioning (fitting) an operating model.