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海洋利用管理学概論

Fishery Population Assessment and Management

Prof. Toshihide Kitakado
(Tokyo University of Marine Science and Technology)

Jan 12, 2021 @Online Class

SELF-INTRODUCTION

- Professor at the Department of Marine Biosciences of Tokyo University of Marine Science and Technology (Lab name is “fishery population analysis”)
- I graduated from a department of mathematical education and then learned probability and theoretical statistics more intensively in grad course
- Currently working for fishery population assessment and management for several species such as marine mammals, tuna, Pacific saury, tropical eels etc.
- Current positions in international organizations
  - Chair of the Scientific Committee in IOTC
  - Chair of the Small Scientific Committee on Pacific saury in NPFC
  - Chair of Ecosystem modelling working group in IWC (Ex-chair of the Scientific Committee of IWC)

CONTENTS

This week

1. Brief introduction of fishery population assessment and management

2. Overview of stock assessment

Next week

3. Overview of management strategy evaluation (MSE)

Please submit your report no later than Jan 26th

- Email address: kitakado@kaiyodai.ac.jp
- Title: TUMSAT_yourID_yourName
- File name (attachment): TUMSAT_HW_yourID_yourName.doc
- Content: summary of my two classes (2 page, 1 for each, in Japanese or English)

1. Brief introduction of fishery population assessment and management

QUICK QUESTIONS

Actually, at the beginning of my lecture, I wanted to discuss with you about the following questions to increase your motivation of learning the topics this and next week:

① Imagine that you are a fishery officer in charge of management of fishery for a species. What kind of information do you want to get from your scientists?

② Imagine that you are a fishery scientist in charge of management of fishery population. What kind of information do you need for your scientific works to provide management advices to your officer?

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OUTCOMES OF DISCUSSION (1)

Here are answers when I asked the same questions in a remote class for a Taiwanese university last month (not necessarily perfect and correct)

① Imagine that you are a fishery officer in charge of management of fishery for a species. What kind of information do you want to get from your scientists?

- Abundance of fish (biomass, population size??)
- Population status is healthy or dangerous situation???? Endangered or not??
- Catch information by fisheries
- Length and weight of fish caught by fisheries
- Environmental conditions (Sea surface temperature, Chl-A, salinity…..)
- How to protect and manage the populations (management advice)
- How to estimate the necessary quantities?
- Extents of mortality (with respect to fishery, by-catch, natural mortality, predation by predators, …)
- Where is the habitat, and its condition
- Not so comprehensive, rather easy to understand the current situation? ….

OUTCOMES OF DISCUSSION (2)

② Imagine that you are a fishery scientist in charge of management of fishery population. What kind of information do you need for your scientific works to provide management advices to your officer?

- Density and abundance of fish in the fishing ground and spawning grounds (by sampling etc.)
- Birth and mortality rates
- Habitat characteristics with respect environmental conditions or geography in the study area
- Fishing gear and fisheries types (longline, trawl, purse seine, gillnet, handline, pole and line,…)
- Growth and age/size-composition
- Resource situation
- Population spatial distribution
- Marine protected area
- Logbook information from fishery, including biological and operational information (size, gender, location, efforts, day,..)
- Is funding available to conduct the research and field surveys
- ….

CHARACTERISTICS OF FISHERY POPULATION

- Compared to terrestrial species, fish species has a larger resilience (反発力)
- At the same time, fish species is not infinitely available
- High demand of fish and fishery product now
- Without management, there is a higher chance to make it depleted or collapsed
- Such a depletion can be also occurred sequentially over several associated species

"Race for Fish" and "Race to Fish"

Rapid worldwide depletion of predatory fish communities

Ransom A. Myers & Boris Worm — Nature 2003

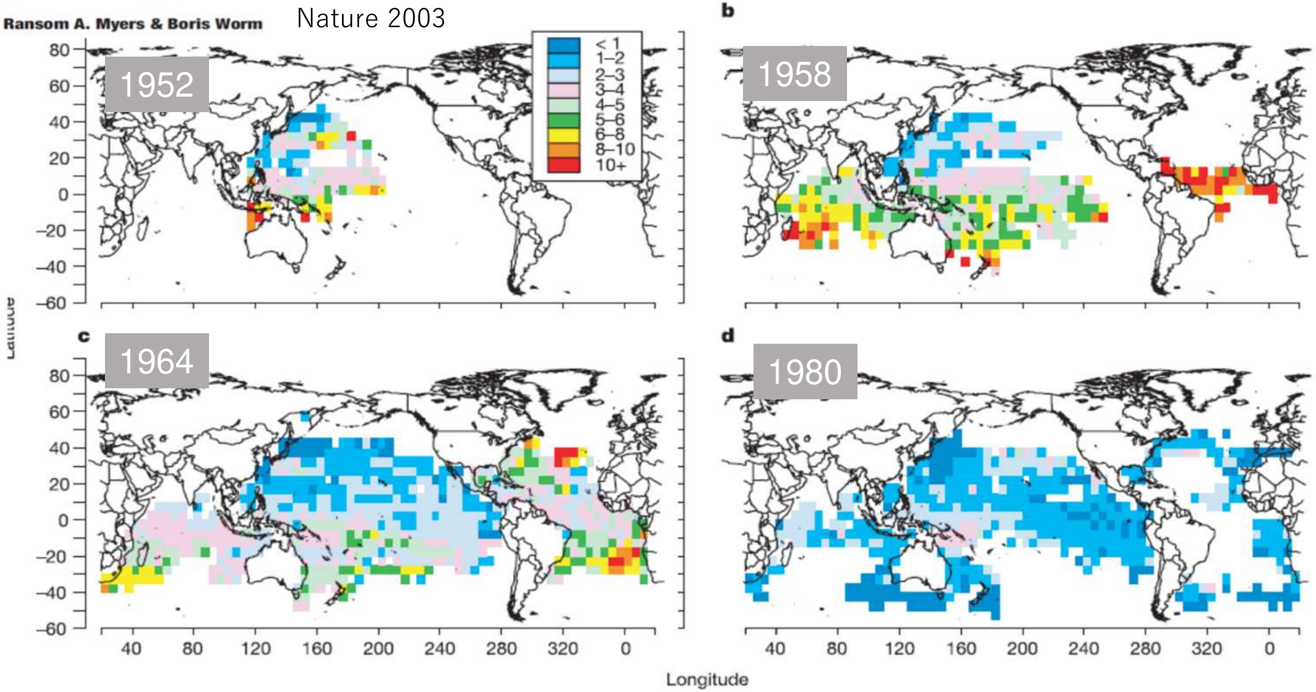


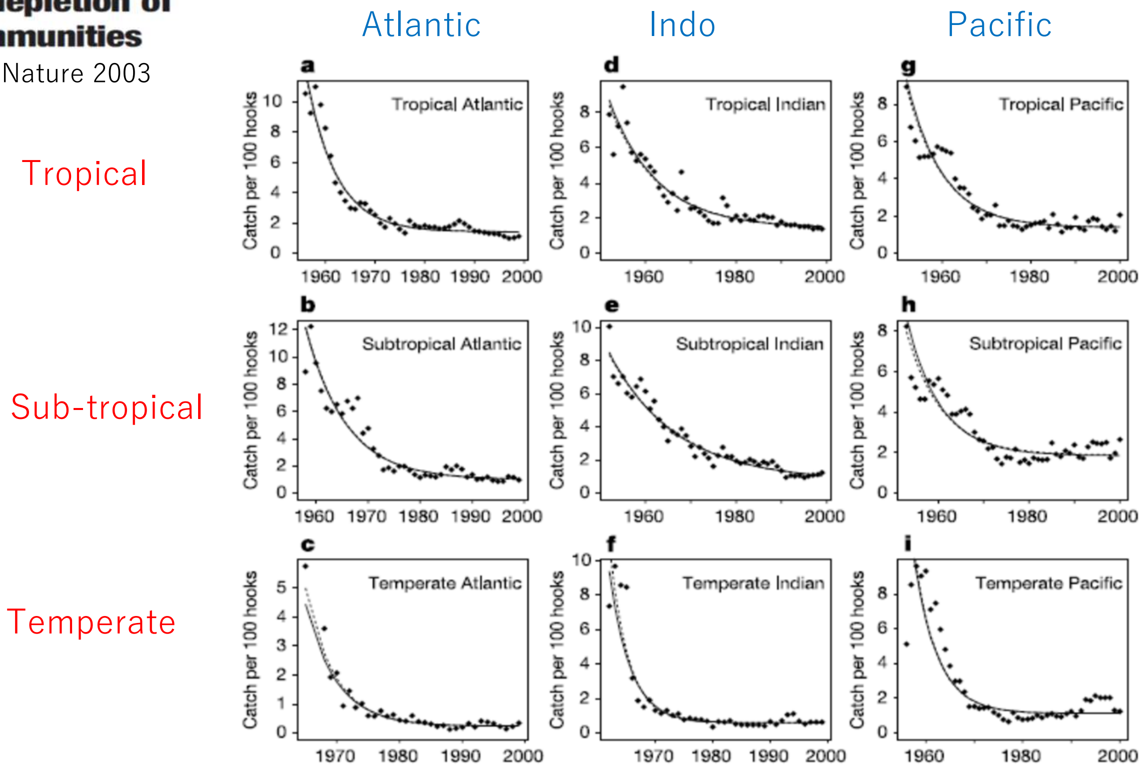
Figure 2 Spatial patterns of relative predator biomass in 1952 (**a**), 1958 (**b**), 1964 (**c**) and 1980 (**d**). Colour codes depict the number of fish caught per 100 hooks on pelagic longlines set by the Japanese fleet. Data are binned in a global 5° × 5° grid. For complete year-by-year maps, refer to the Supplementary Information.

TRENDS OF COMMUNITY BIOMASSES

Rapid worldwide depletion of predatory fish communities

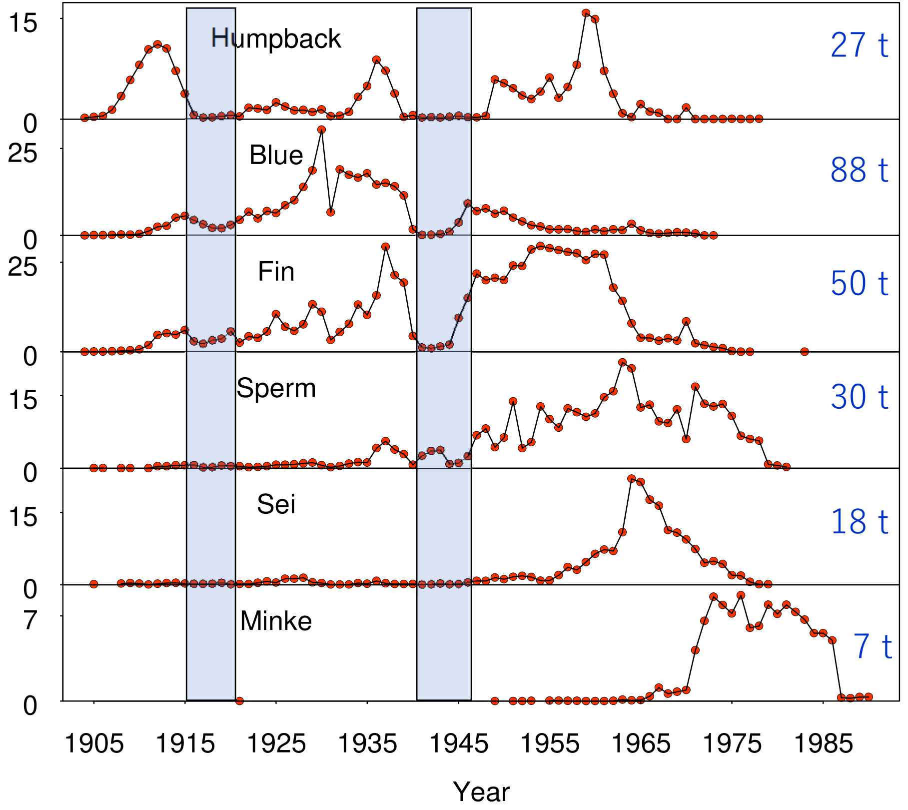
Ransom A. Myers & Boris Worm

Nature 2003



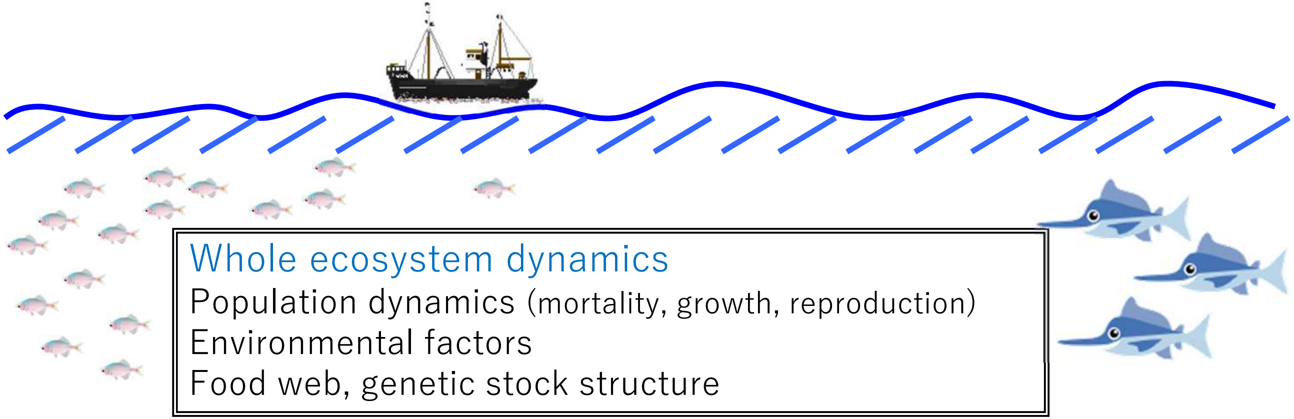
Historical catch of whales in Antarctic

"Race for whales"
in Antarctic
(Catches in thousands)



Hilborn et al. (2003) Annual Review of Environment and Resources 28:359-399.

Fishery management



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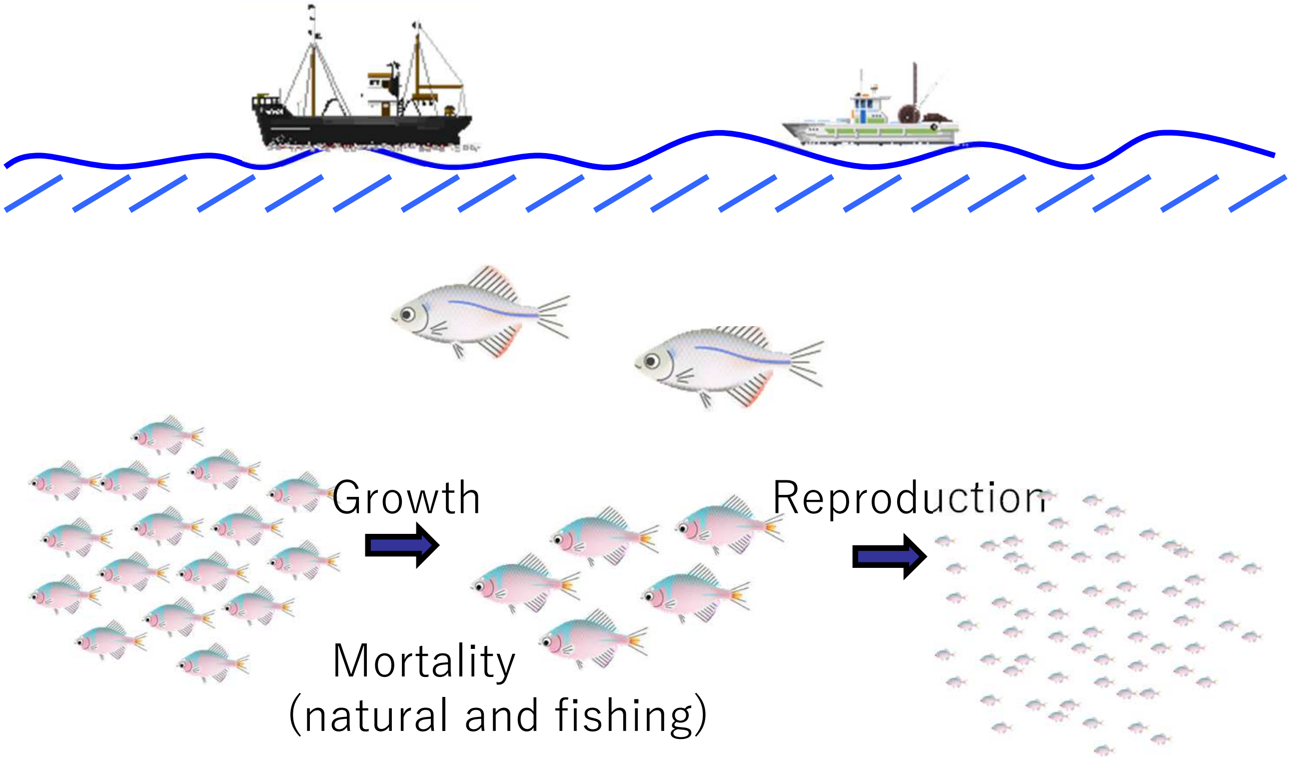
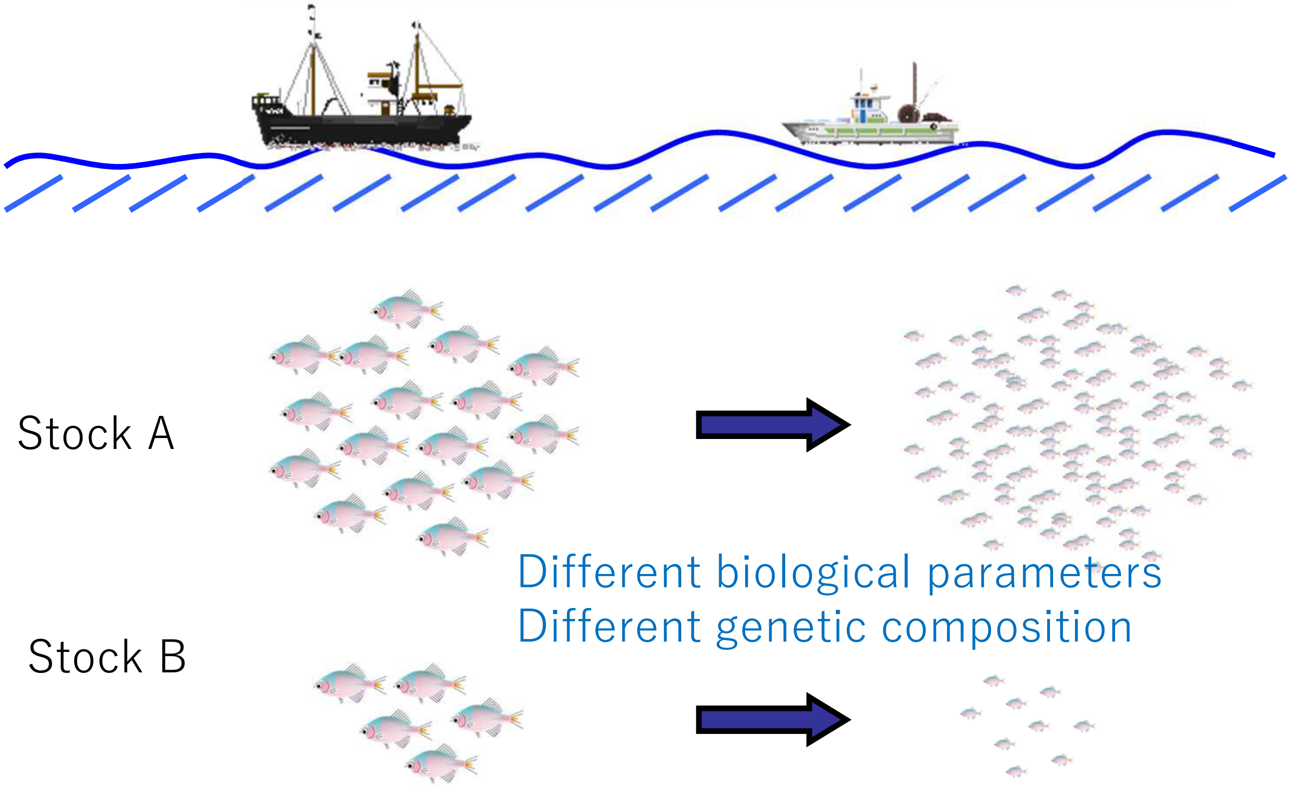
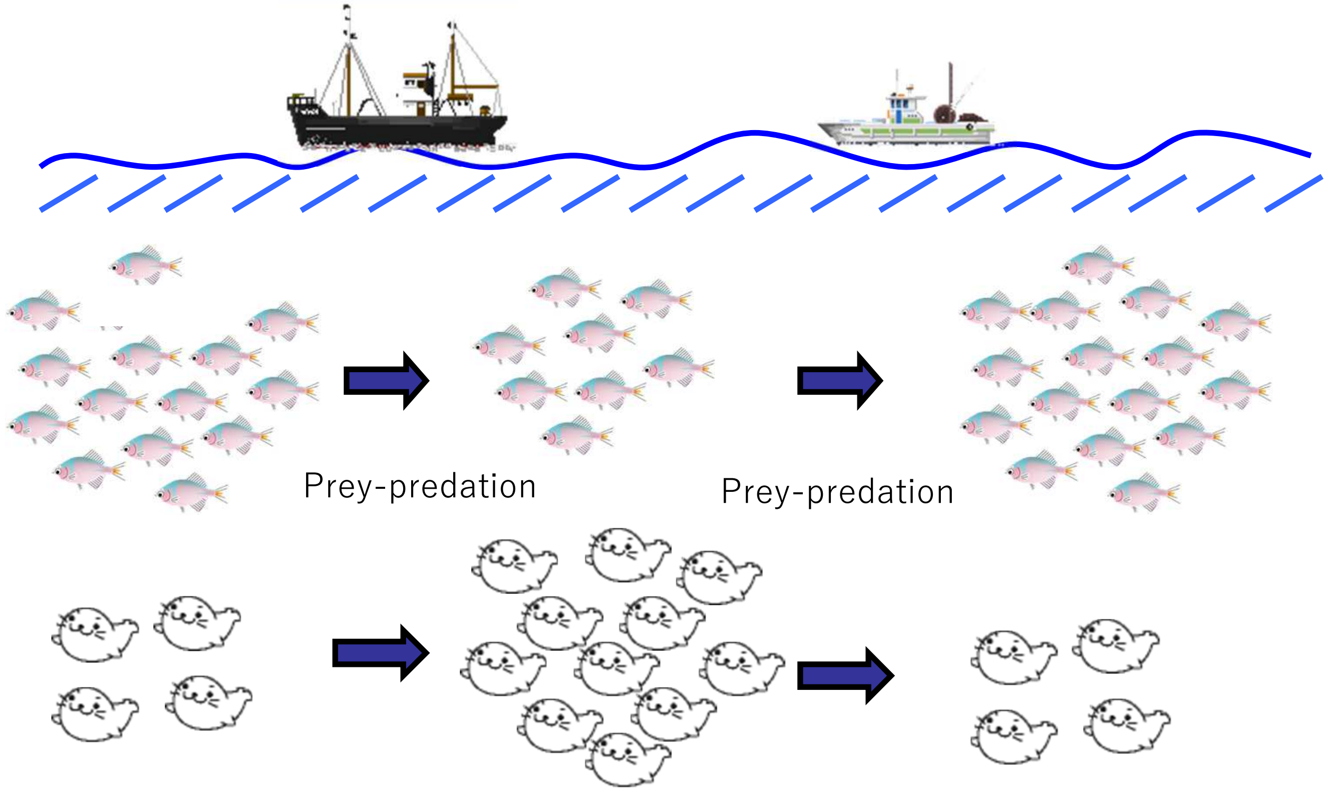
FISHERY MANAGEMENT



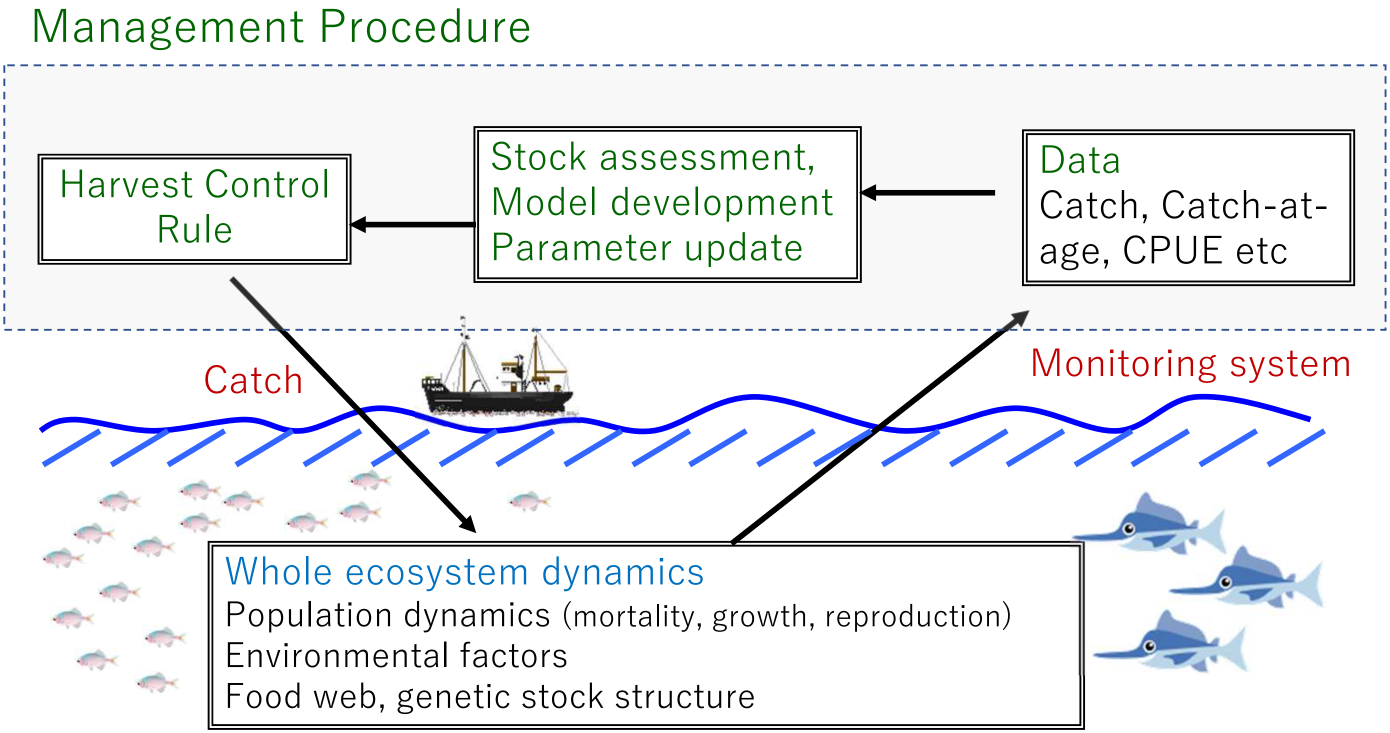
Fishery management



Fishery management



Fishery management

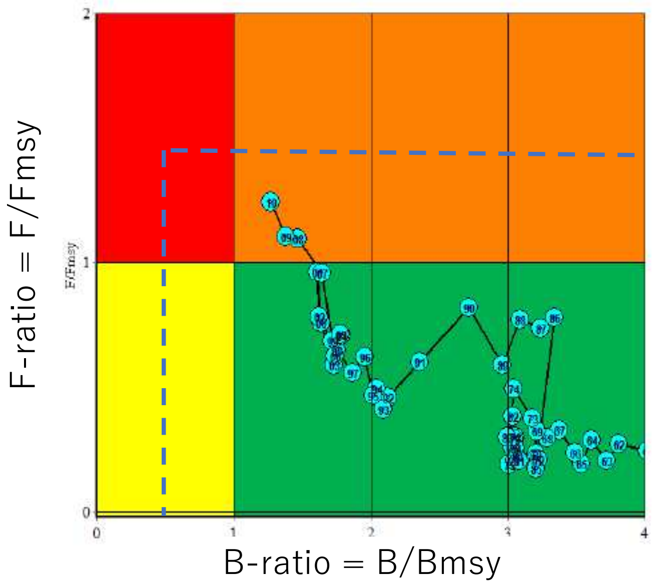


2. Overview of Stock Assessment

Kobe plot

By looking at the following figure

- What do you say about the population/fishery status?
- What is your possible measure for this fishery?



B-ratio = B/Bmsy

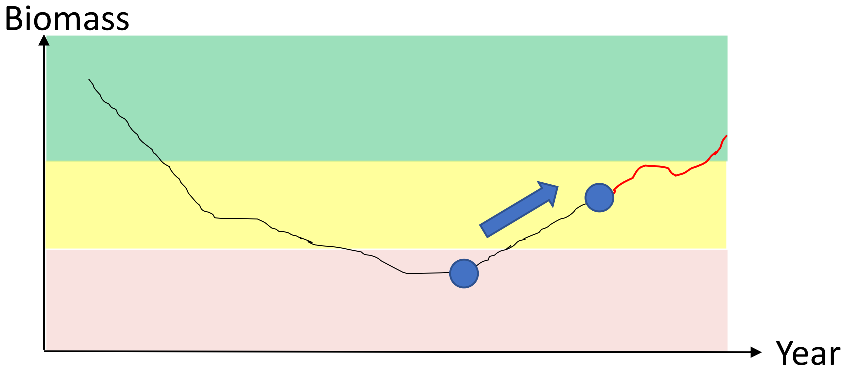
B-ratio <1
or
B-ratio > 1 ?

F -ratio = F/Fmsy

F-ratio <1
or
F-ratio > 1 ?

WHAT IS THE OBJECTIVE OF STOCK ASSESSMENT?

- To know current & absolute population size (or biomass)
- To know current but relative population size to past (information on the trend)
- To know whole (or even recent) time trajectory of the population size
- To know current population status relative to reference points
- To simulate future population dynamics …



WHAT KIND METHODS SHOULD BE USED???

The answer depends on

- Objectives (and what information your managers want to get from you!)
- Biological and ecological natures of target species (e.g. life span and history, migration, mortality, …)
- Types of fisheries
- Data availability and quality (but "Data" are not same as "knowledge")
- Spatial and temporal range of habitat and its use by fisheries
- Capacity of analysts
- Software availability …

Several data/methods to know the population status

- Direct survey for estimating the population size and biomass
  - Quadrat method
  - Line transect method (strip and point transect)
- Mark-recapture
  - Physical and genetic tagging
- CPUE series (fishery-dependent index)
  - Trend in abundance
  - Depletion method (De Lury method)
- Catch-at-age data
  - Virtual population analyses
  - Statistical catch-at-age

and more…

CPUE

CPUE = Catch per Unit Effort

Suppose the number of fishing vessels as a unit of effort

- Greater the efforts (the number of vessels), higher the catch
- Greater the population size, higher the catch

⇒ If we use a formula to express the above two issues,

漁獲量 ∝努力量(e.g. 漁船隻数) × 資源量

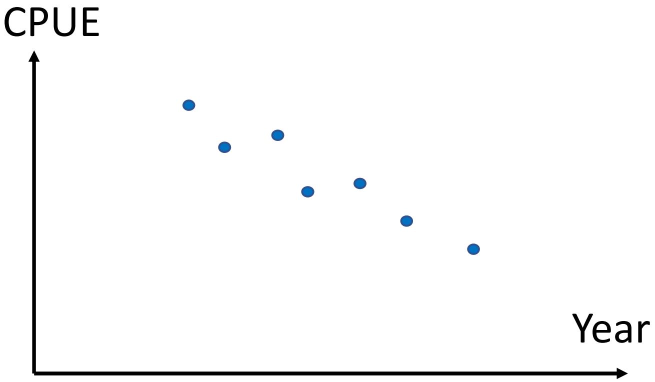
Catch ∝ Efforts × (Population size or biomass)

⇒ Then

CPUE = Catch/Efforts = 漁獲量/努力量 ∝ 資源量

So, CPUE is a kind of index of population size (or biomass) depending on the unit of catch

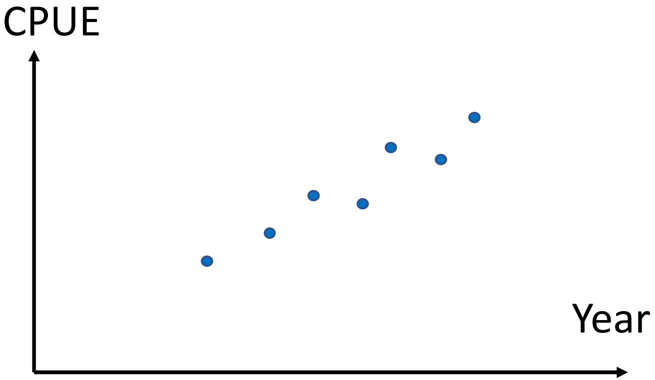
INFORMATION FROM TREND OF CPUE



CPUE is decreasing over time

⇒ Population size is decreasing

⇒ Do we need to reduce catch to conserve ?
or
Still OK to keep the current catch level ?



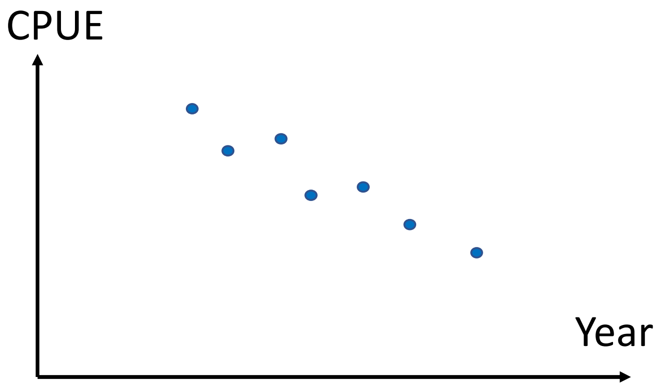
CPUE is increasing over time

⇒ Population size is increasing

⇒ May we increase the catch level ?
or
Still on the way of recovery ?

Answer depends on the population size itself and some reference points !

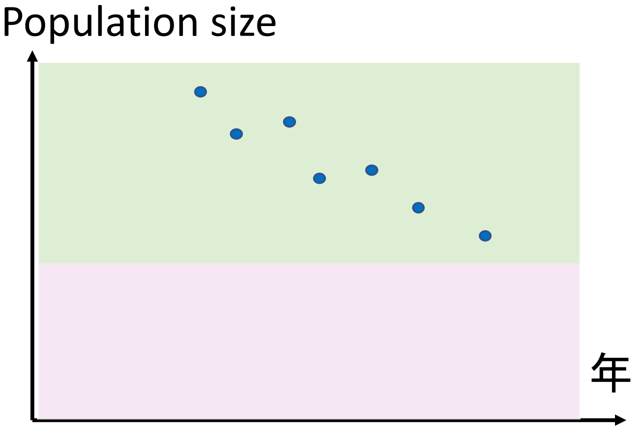
Information from trend of CPUE

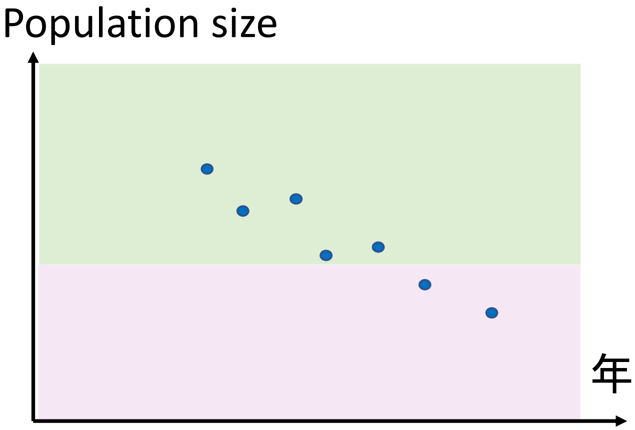


CPUE is decreasing over time

⇒ Population size is decreasing

⇒ Do we need to reduce catch to conserve ?
or
Still OK to keep the current catch level ?





We need to conduct stock assessment to describe population dynamics！

The concept of "surplus production"

The change in a population biomass
(Assume no immigration and emigration)

(Next year's biomass)

= (current biomass) + (Recruitment) + (Growth)

– (Natural mortality) – (Catch)

= (current biomass) + (Surplus) – (Catch)

$$B_{t+1} = B_t + g(B_t) - C_t$$

次年資源量 ＝ 現存資源量 ＋ 生産量 ー 漁獲量

A SIMPLE RELATIONSHIP BETWEEN STOCK BIOMASS

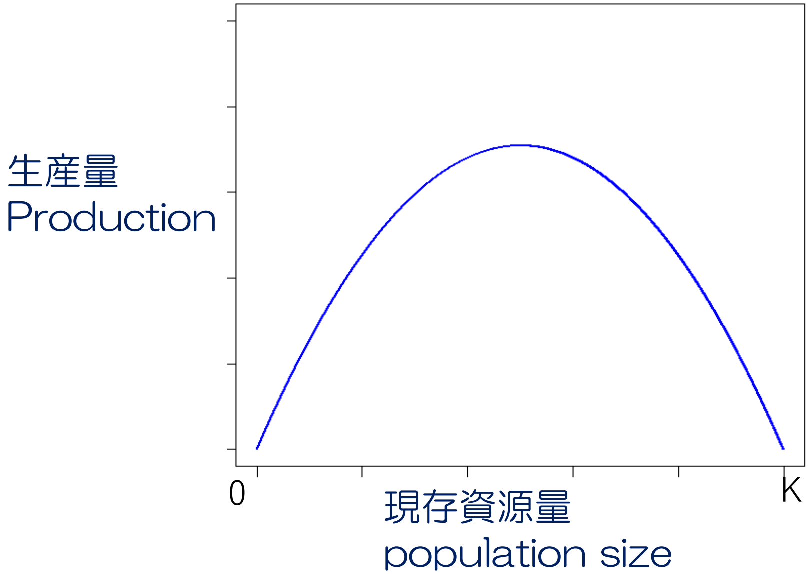
次年資源量 ＝ 現存資源量 ＋ 生産量 ー 漁獲量

Schaefer model (logistic model)

$$B_{t+1} = B_t + r B_t \left(1 - \frac{B_t}{K}\right) - C_t$$

r: Intrinsic rate of natural increase

K: Carrying capacity



Population is sustainable
if you catch as same as production !

$$B_{t+1} = B_t + g(B_t) - C_t$$

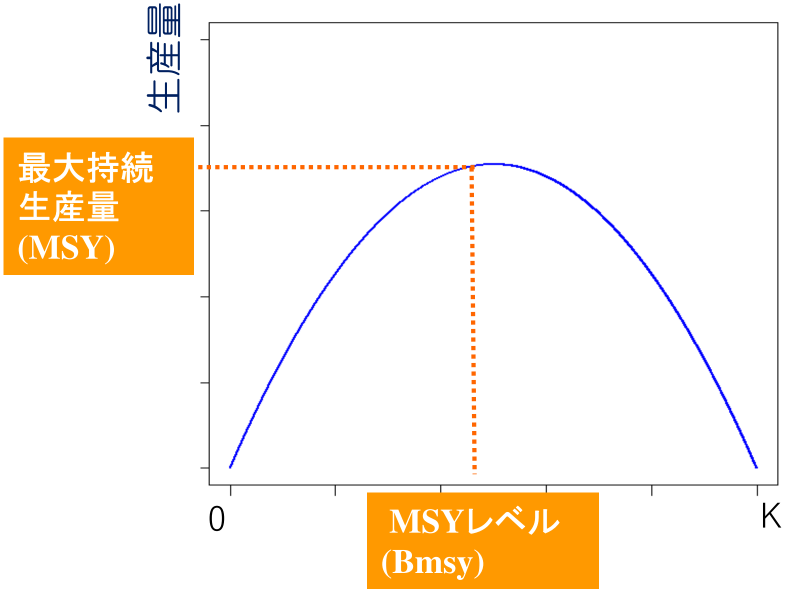
$$C_t = g(B_t) \longrightarrow B_{t+1} = B_t$$

Sustainable Yield

次年資源量 ＝ 現存資源量 ＋ 生産量 － 漁獲量

Schaefer model (logistic model)

$$B_{t+1} = B_t + r B_t \left(1 - \frac{B_t}{K}\right) - C_t$$



$$C_t = r B_t \left(1 - \frac{B_t}{K}\right)$$

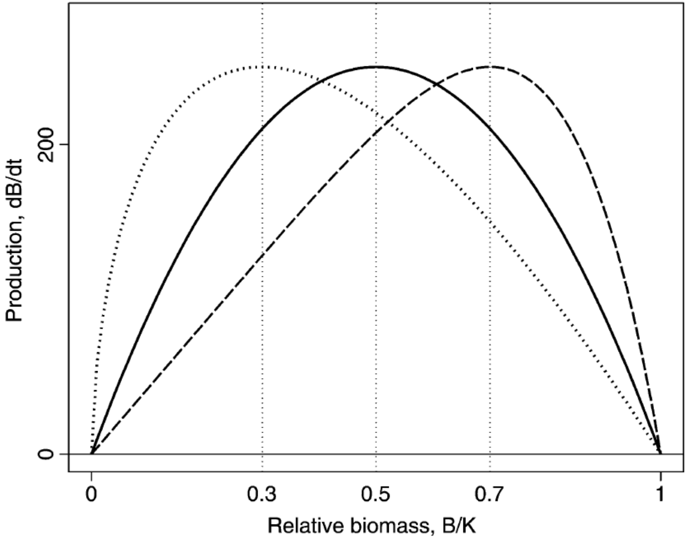
$$\Rightarrow B_{t+1} = B_t$$

$$Bmsy = ?$$

$$MSY = ?$$

Other functions

$$B_{t+1} - B_t = r\,B_t \left(1 - \left(\frac{B_t}{K} \right)^z \right)$$



From Prager (2002)

REMEMBER CPUE

CPUE = Catch per Unit Effort

[漁獲量 Catch] ∝ [努力量 Effort] × [資源量 Abundance]

[漁獲量 Catch] = [比例定数 coefficient] × [努力量 Effort] × [資源量 Abundance]

(漁具能率)

漁獲強度(fishing intensity)

$$MSY = rK/4$$

$$= \boxed{} \times \boxed{K/2}$$

$$= \boxed{Fmsy} \times \boxed{Bmsy}$$

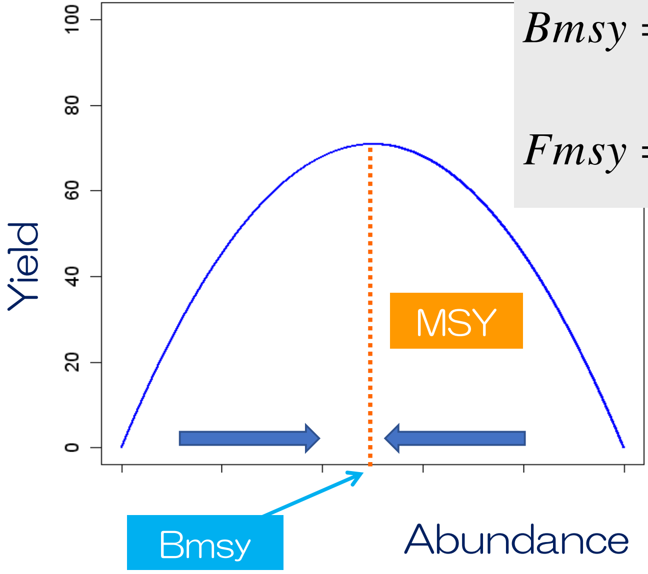
$$Fmsy = \boxed{}$$

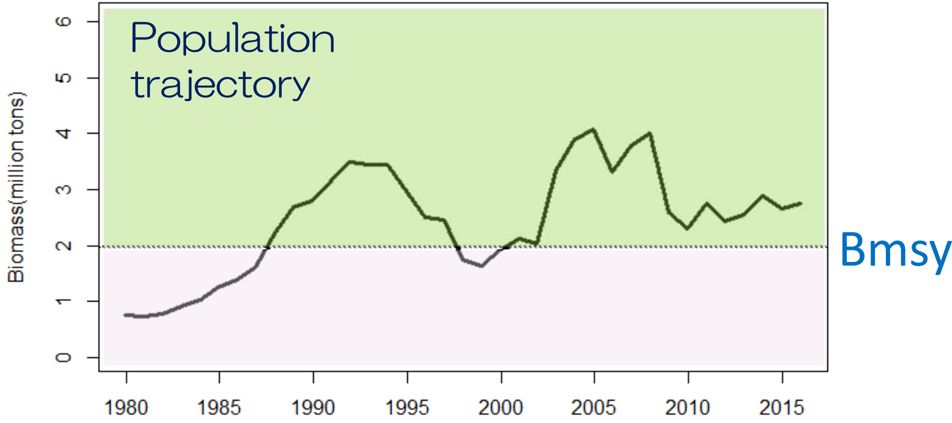
REFERENCE POINTS

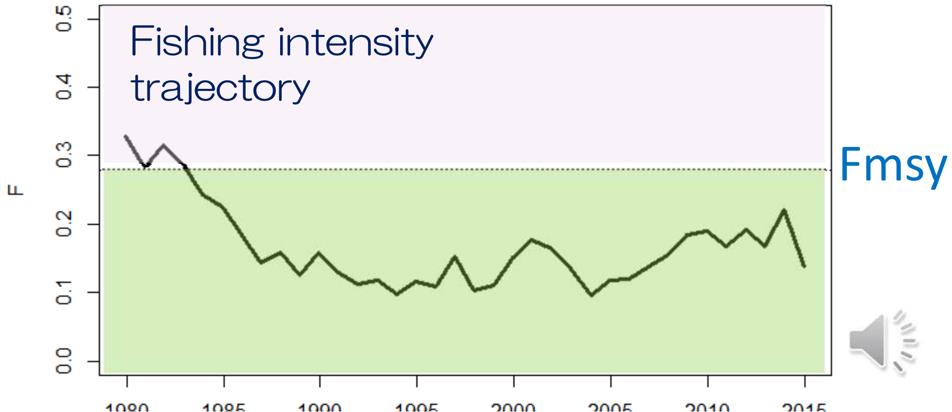
$$B_{t+1} = B_t + r\,B_t\left(1 - \frac{B_t}{K}\right) - C_t$$

$$Bmsy = \frac{K}{2}$$

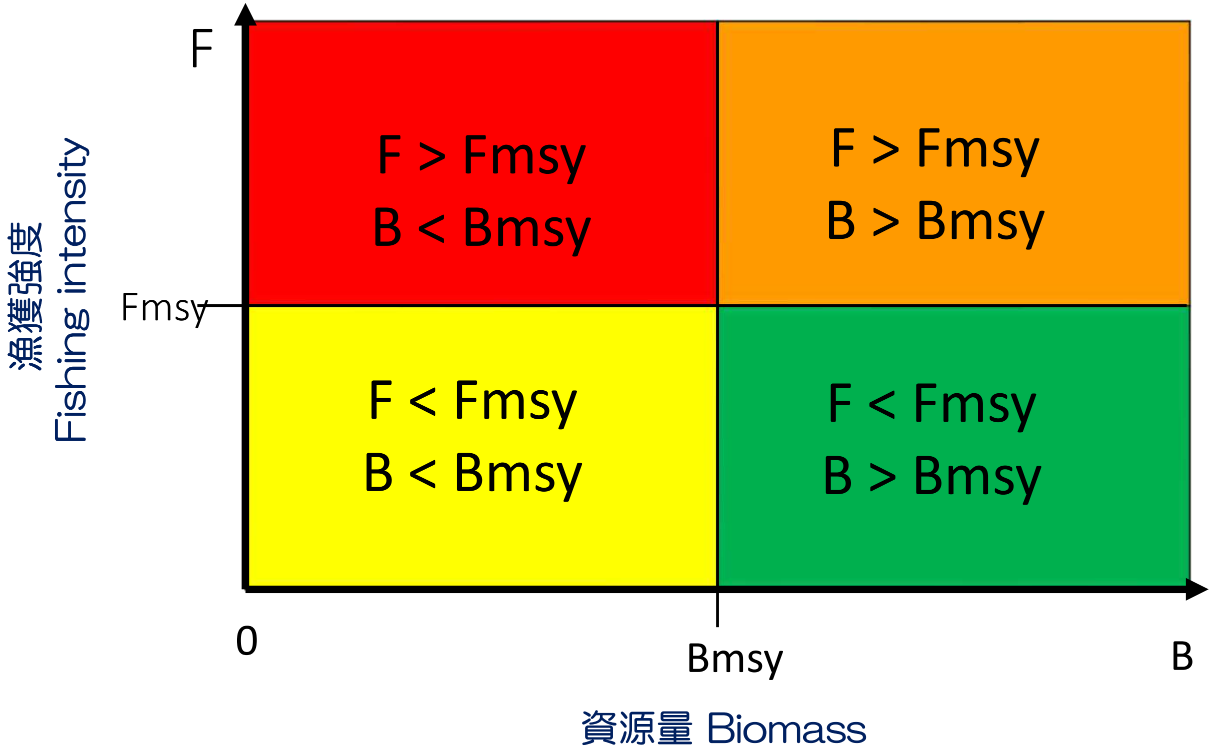
$$Fmsy = \frac{r}{2}$$



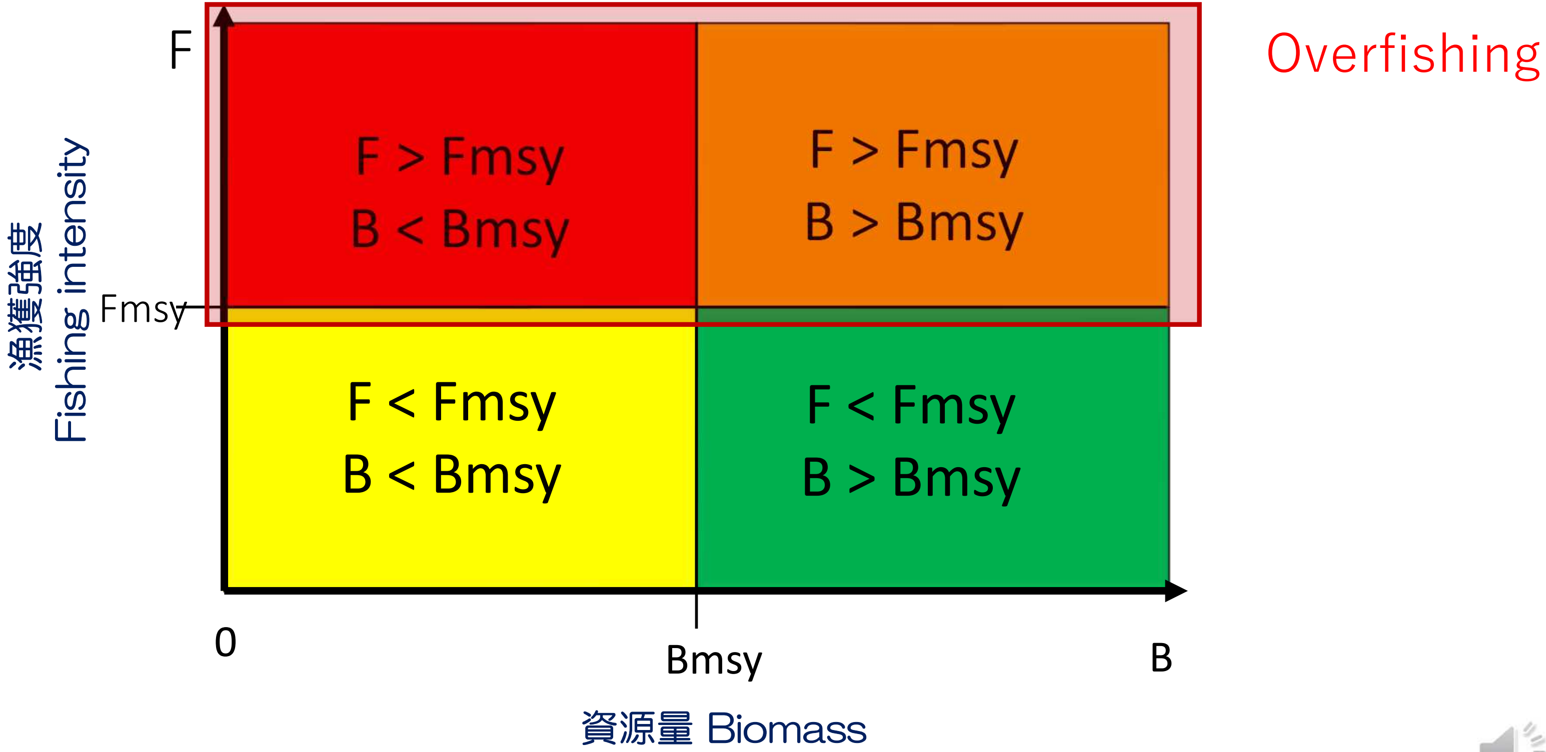




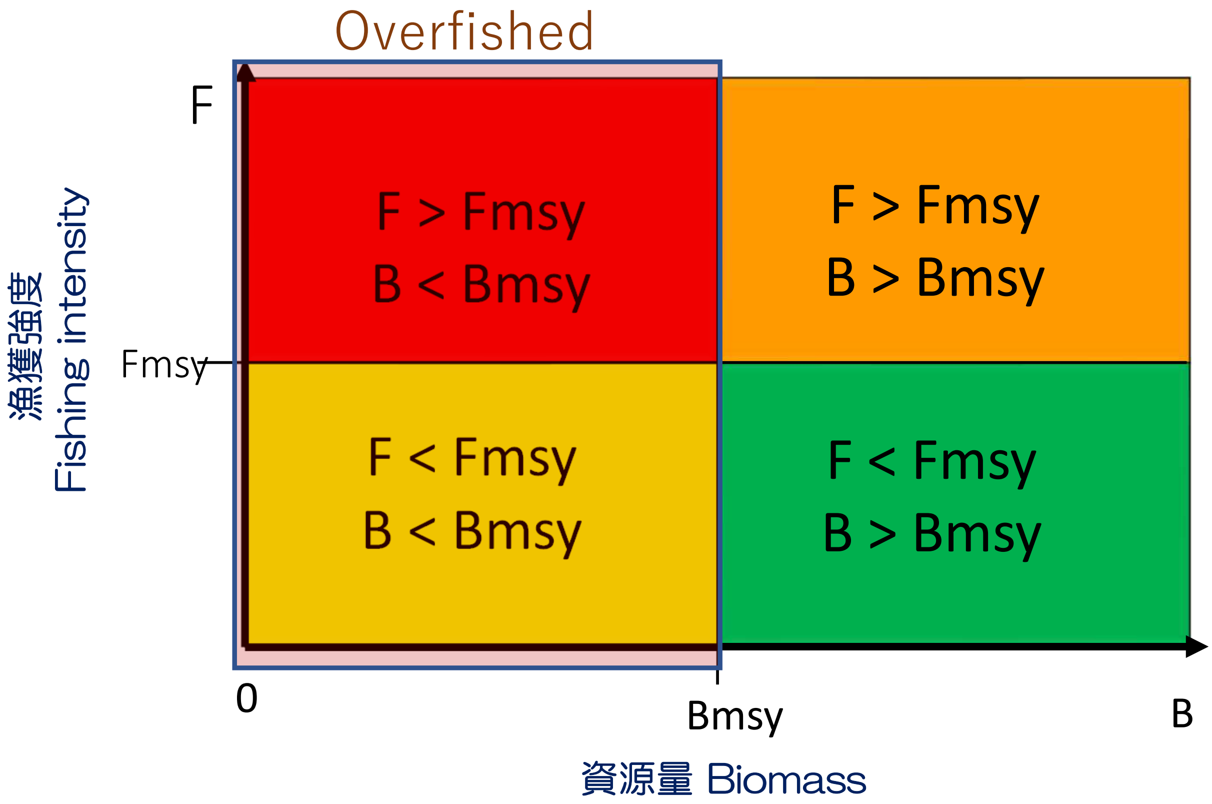
Kobe Plot


F
F > Fmsy
B < Bmsy
F > Fmsy
B > Bmsy
Fmsy
F < Fmsy
B < Bmsy
F < Fmsy
B > Bmsy
0
Bmsy
B
漁獲強度 Fishing intensity
資源量 Biomass

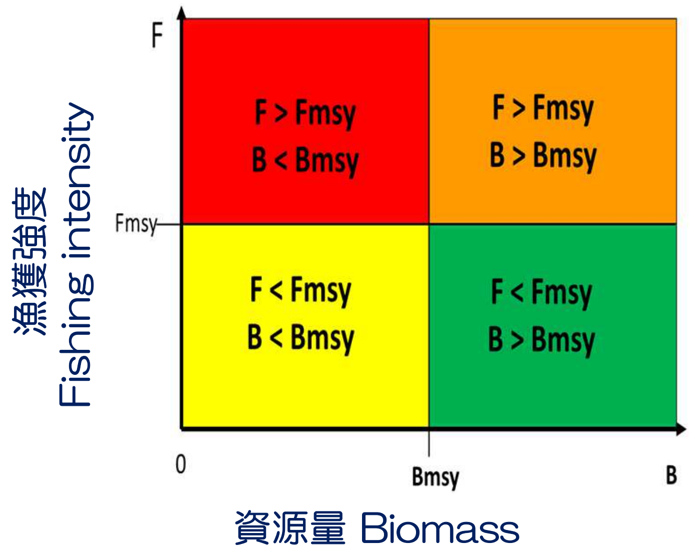
Kobe Plot


F
Fmsy
漁獲強度
Fishing intensity
F > Fmsy
B < Bmsy
F > Fmsy
B > Bmsy
F < Fmsy
B < Bmsy
F < Fmsy
B > Bmsy
Overfishing
0
Bmsy
B
資源量 Biomass

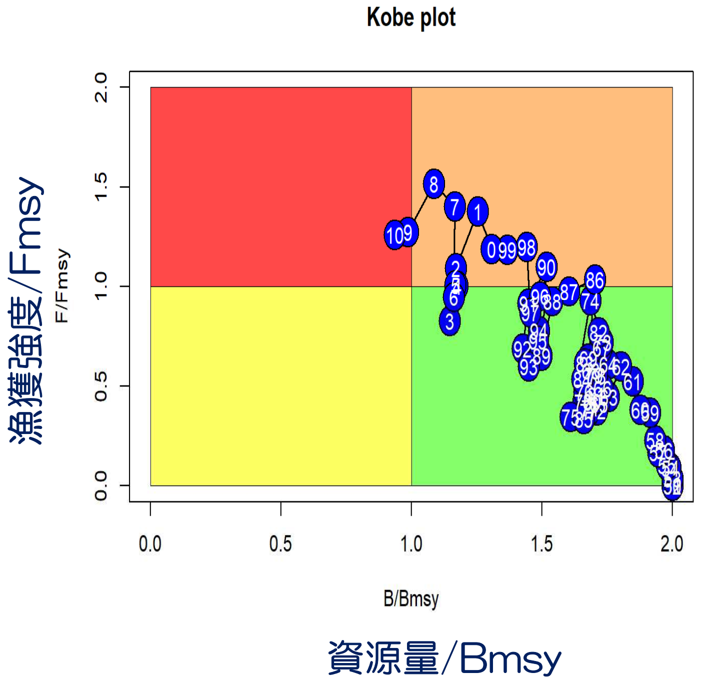
Kobe Plot


Overfished
F
Fmsy
F > Fmsy
B < Bmsy
F > Fmsy
B > Bmsy
F < Fmsy
B < Bmsy
F < Fmsy
B > Bmsy
漁獲強度
Fishing intensity
0
Bmsy
B
資源量 Biomass

Kobe plot



F
Fmsy
F > Fmsy
B < Bmsy
F > Fmsy
B > Bmsy
F < Fmsy
B < Bmsy
F < Fmsy
B > Bmsy
0
Bmsy
B
漁獲強度
Fishing intensity
資源量 Biomass



Kobe plot
F/Fmsy
B/Bmsy
漁獲強度/Fmsy
資源量/Bmsy
0.0
0.5
1.0
1.5
2.0

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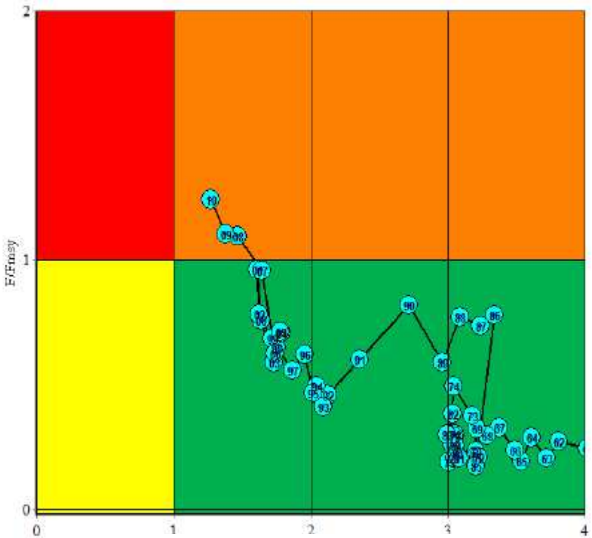
Kobe plot 1

By looking at the following figure

- What do you say about the population/fishery status?
- What is your possible measure for this fishery?

F-ratio = F/Fmsy



B-ratio = B/Bmsy

B-ratio = B/Bmsy

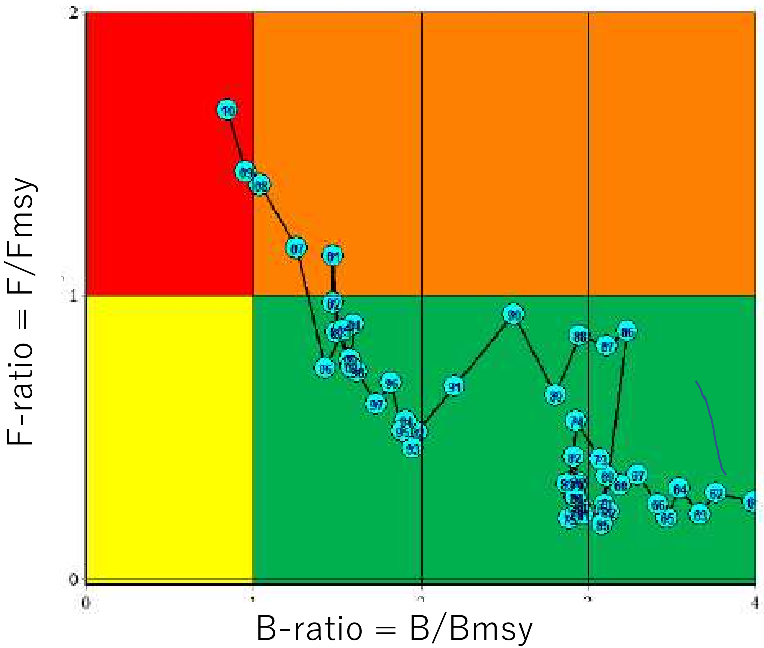
B-ratio <1
or
B-ratio > 1 ?

F -ratio = F/Fmsy

F-ratio <1
or
F-ratio > 1 ?

KOBE PLOT 2

How about this?



7. Presentation of stock assessment results

SC in 2018

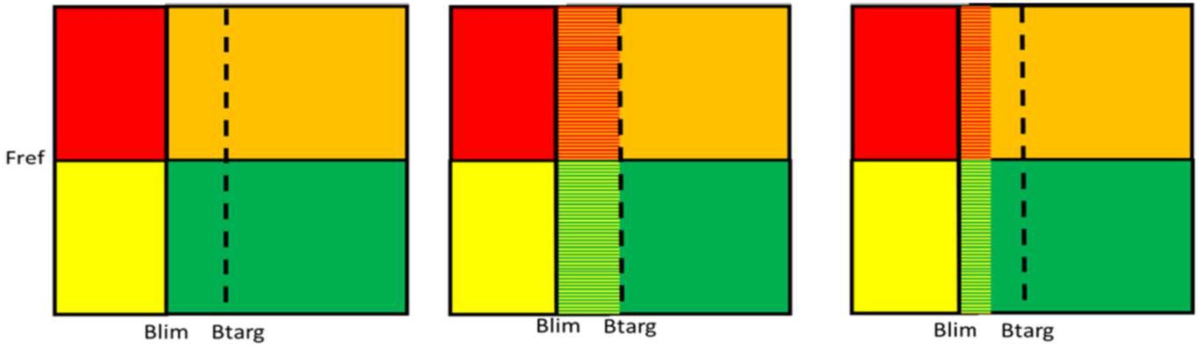
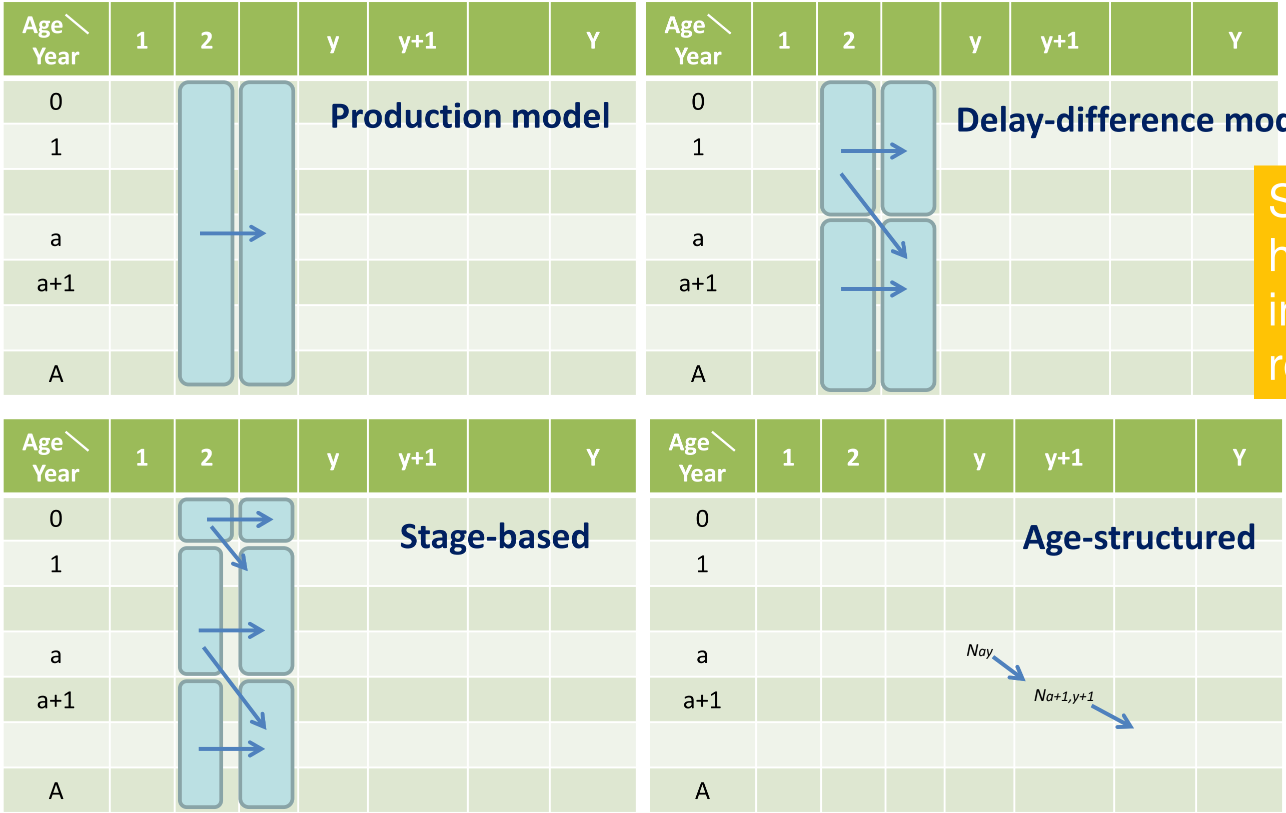


Fig. 1: Three examples of modified Kobe Plots in which there is a target biomass, Btarg, and a reference F (Fref) such as FMSY. In each plot, the red quadrant is based on biomass being below the limit (Blim) rather than below a target biomass. The plot in the middle retains the four colours, but contains red-orange and yellow-green "buffer zones" between the target and limit. In the plot on the right, the buffer zone starts somewhat below the target biomass to account for natural fluctuations of the stock around the target. Note: This figure is from the ISSF Stock Assessment Workshop report (IOTC-2018-WPM09-INF06).

157. However, the SC **NOTED** the Kobe plot has been used to formulate the IOTC (Resolution 15/10) and ICCAT stock conservation decision frameworks and also to provide advice to various commissions. The SC further noted that the Kobe plot is more or less the same across RFMOs and there is a risk that if modified they may no longer be consistent with the common understanding as to how they were initially developed and have been used until now. The SC therefore **AGREED** that any revision or modification to the Kobe plot requires careful considerations and ideally this type of modified display should be coordinated with other tRFMOs through a Kobe process.

BASICALLY "AGE-STRUCTURED" BUT REALITY IS...



Sometimes, we may have a benefit of use of information of recruitment

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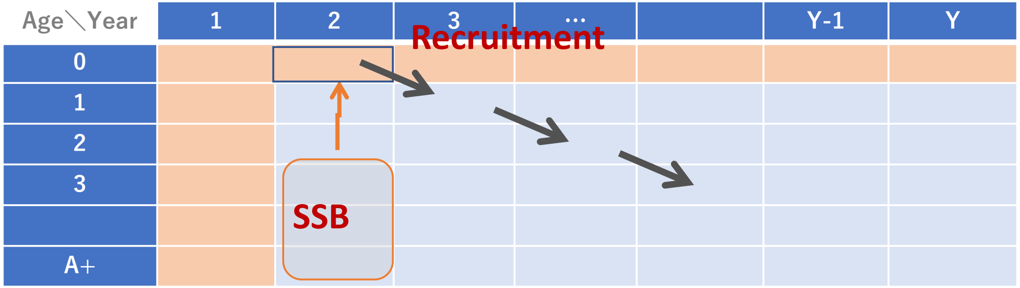
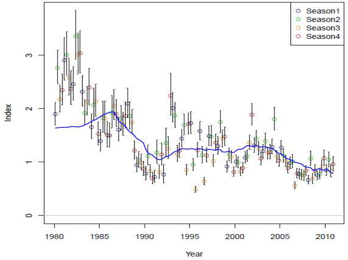
VERY QUICK OVERVIEW OF SS FRAMEWORK

Age-structured pop dynamics

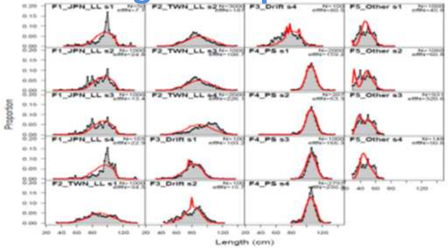


Typical data

CPUE



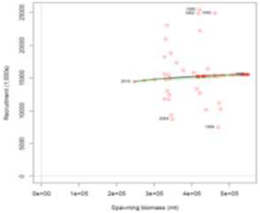
Length composition



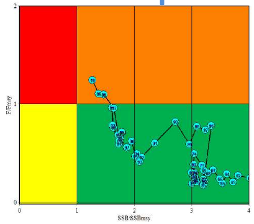
Some outputs

SSB

Spawner - Rec



KOBE plot



Reasons why SS3 has been getting a common approach

- Flexibility in data

  Basic data: Index, Size
  Further data: conditional age-at-length, tagging, prior,…
- Flexibility in data
  - Growth, S-R, M, selectivity, …
  - by-fleet, by-gender, spatial, …
  - time-varying, time-block, …
- Peer-reviewed
- Evaluation by intensive simulation
- Graphical outputs
- Consistency in evaluation of errors
- Reproducible

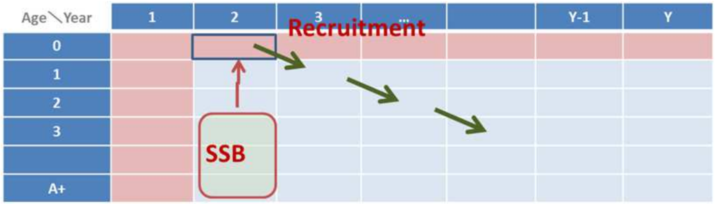
SOME DIFFICULTY

In assumption

- Steepness (h)
- Natural mortality (M)
- Standard error of stochastic variation in recruitment (sigmaR)
- Variance of growth
- Effective sample size
- Selectivity (time-varying?)

Basic population dynamics (age-structured)

- Gender [γ] (yes, no)
- Time unit [y] (year, quarterly …)
- Age [a=1,2,…,A]
- Fishery [f]



$$N_{y+1,\gamma,a,} = \begin{cases} cR_{y+1,\gamma,0} & \text{if } a = 0 \\ N_{y,\gamma,a-1} e^{-Z_{y,t,\gamma,a}} & \text{if } 1 \le a \le A-1 \\ N_{y,\gamma,A-1} e^{-Z_{y,t,\gamma,A-1}} + N_{y,\gamma,A} e^{-Z_{y,t,\gamma,A}} & \text{if } a = A \end{cases} \qquad (A.1.20)$$

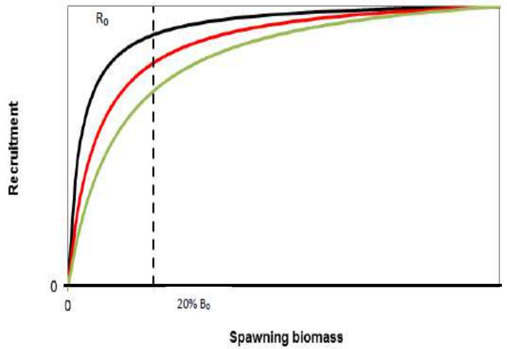
$$Z_{y,t,\gamma,a} = M_{\gamma,a} + \sum_f \left(S_{f,\gamma,a} F_{y,t,f} \right) \qquad (A.1.21)$$

M: natural mortality (several options)
S: selectivity by fishery and year (many options!)
F: Fishing intensity

RECRUITMENT

- BH

$$R_y = \frac{4hR_0SB_y}{SB_0(1-h)+SB_y(5h-1)} e^{-0.5b_y\sigma_R^2+\tilde{R}_y} \quad \tilde{R}_y \sim N(0;\sigma_R^2)$$



$$SB_y = \sum_{a=0}^{A} N_{y,\mathrm{fem},a} f_a$$

h (steepness)

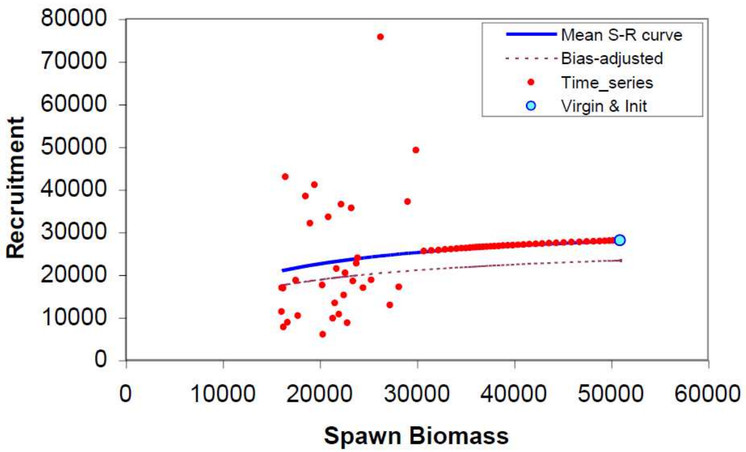
- Ricker

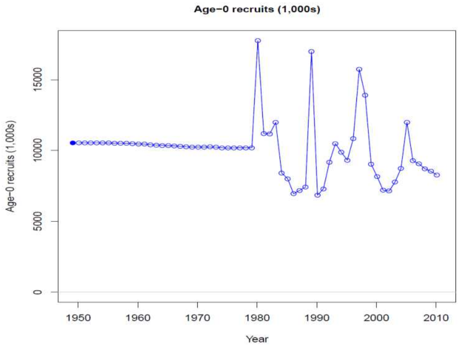
$$R_y = \left(\frac{R_0SB_y}{SB_0}\right) e^{h(1-SB_y/SB_0)} e^{-0.5b_y\sigma_R^2+\tilde{R}_y} \quad \tilde{R}_y \sim \tilde{N}(0;\sigma_R^2)$$

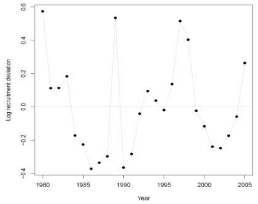
- Hockey-stick

RECRUITMENT

$$R_y = \frac{4hR_0 SB_y}{SB_0(1-h) + SB_y(5h-1)} e^{-0.5 b_y \sigma_R^2 + \tilde{R}_y} \qquad \tilde{R}_y \sim N\left(0; \sigma_R^2\right)$$

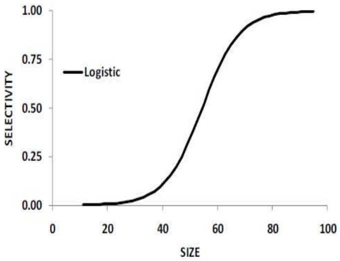


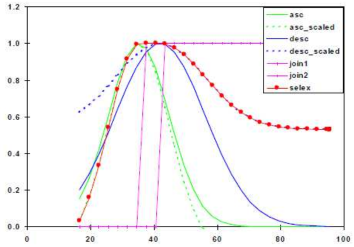


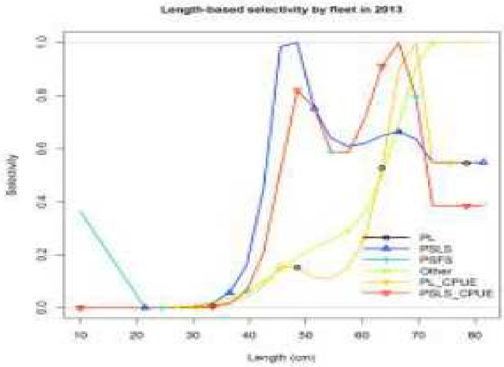


SELECTIVITY

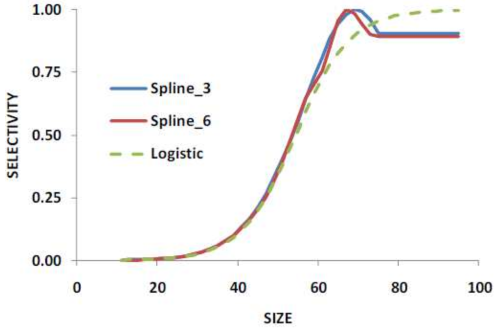
- Several functional forms







- OK to be nonparameteric
- cubic spline
- time-varying



SIZE-SELECTIVITY, GROWTH AND CATCH

- Mean Growth: VB関数 (OK: Richard)

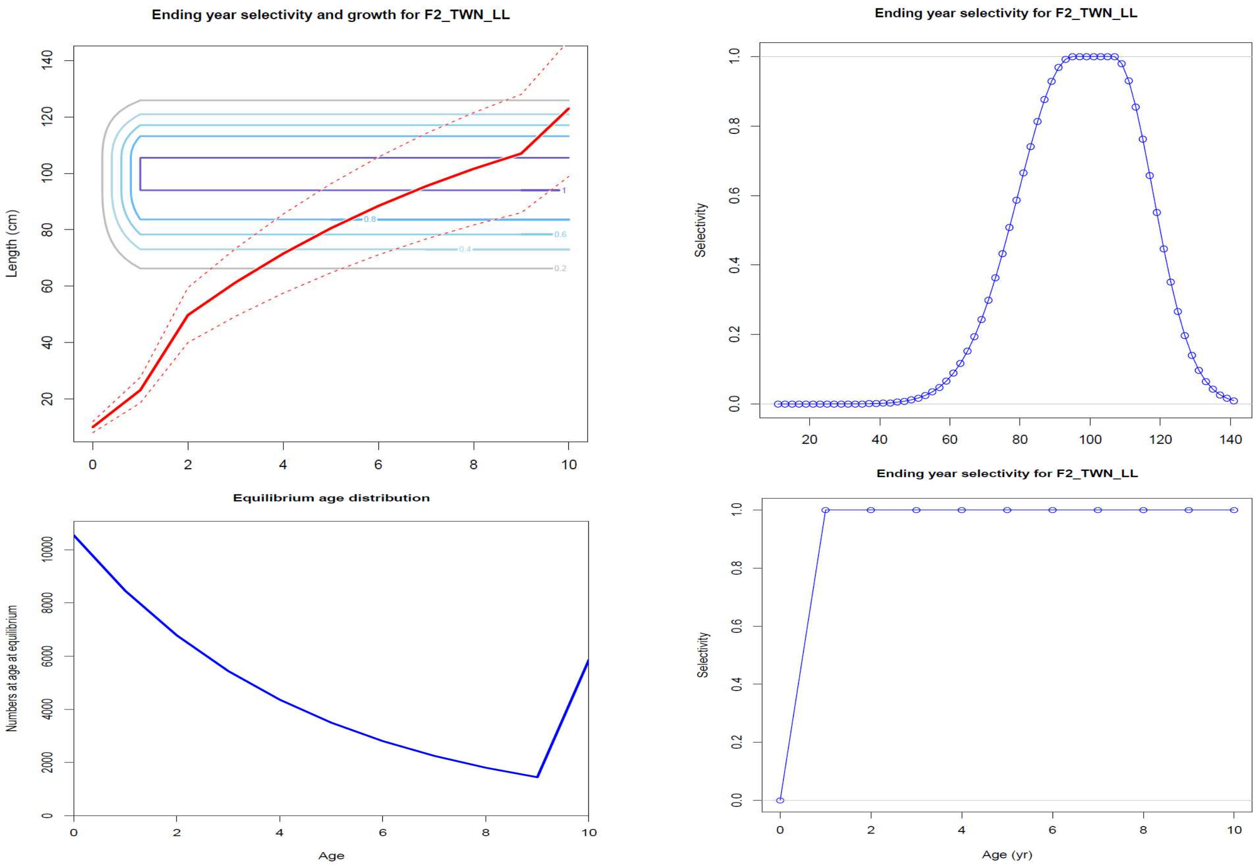
$$L_{y+1,\gamma,a} = L_{y,\gamma,a} + \left(L_{y,\gamma,a-k} - L_{\infty,\gamma}\right)\left(e^{-k_\gamma} - 1\right) \quad \text{for } a < A \qquad (A.1.10)$$

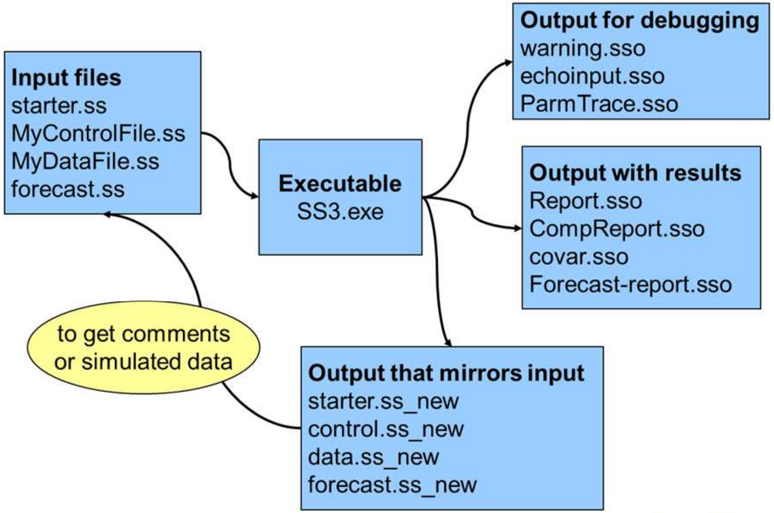
- Growth variation

$$\sigma_{\gamma,a} = \begin{cases} \tilde{L}_{\gamma,a}\left(CV_{1,\gamma}\right) & \text{for } a \le a_3 \\ \tilde{L}_{\gamma,a}\left(CV_{1,\gamma} + \dfrac{\left(\tilde{L}_{\gamma,a} - L_{1,\gamma}\right)}{\left(L_{2,\gamma} - L_{1,\gamma}\right)}\left(CV_{2,\gamma} - CV_{1,\gamma}\right)\right) & \text{for } a_3 < a < a_4 \\ \tilde{L}_{\gamma,a}\left(CV_{2,\gamma}\right) & \text{for } a \ge a_4 \end{cases} \qquad (A.1.13)$$

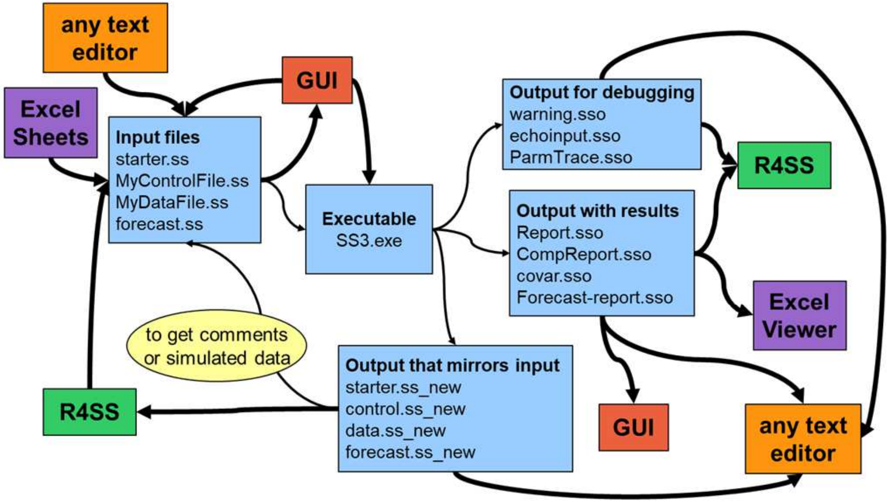
```
1 #_GrowthModel: 1=vonBert with L1&L2; 2=Richards with L1&L2;
0 #_Growth_Age_for_L1
25 #_Growth_Age_for_L2 (999 to use as Linf)

-10 45 21.6552 36 0 10 2 0 0 0 0 0 0 0 # L_at_Amin_Fem_GP_1
40 90 71.6492 70 0 10 4 0 0 0 0 0 0 0 # L_at_Amax_Fem_GP_1
0.05 0.25 0.147282 0.15 0 0.8 4 0 0 0 0 0 0 0 # VonBert_K_Fem_GP_1
0.05 0.25 0.1 0.1 -1 0.8 -3 0 0 0 0 0 0 0 # CV_young_Fem_GP_1
0.05 0.25 0.1 0.1 -1 0.8 -3 0 0 0 0 0 0 0 # CV_old_Fem_GP_1
```

SIZE-SELECTIVITY, GROWTH AND CATCH

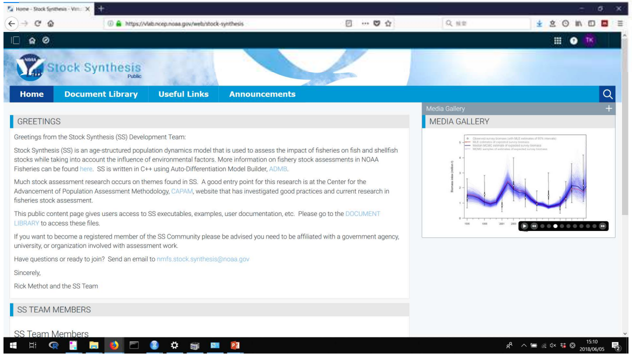




From SS website



From SS website



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CONTROL FILE

```
#C growth parameters are estimated
#C spawner-recruitment bias adjustment Not tuned For optimality
#_data_and_control_files: simple.dat // simple.ctl
#_SS-V3.21d-safe;_06/09/2011;_Stock_Synthesis_by_Richard_Methot_(NOAA)_u
1  #_N_Growth_Patterns
1 #_N_Morphs_Within_GrowthPattern
#_Cond 1 #_Morph_between/within_stdev_ratio (no read if N_morphs=1)
#_Cond  1 #vector_Morphdist_(-1_in_first_val_gives_normal_approx)
#
#_Cond 0  #  N recruitment designs goes here if N_GP*nseas*area>1
#_Cond 0  #  placeholder for recruitment interaction request
#_Cond 1 1 1  # example recruitment design element for GP=1, seas=1, are
#
#_Cond 0 # N_movement_definitions goes here if N_areas > 1
#_Cond 1.0 # first age that moves (real age at begin of season, not inte
#_Cond 1 1 1 2 4 10 # example move definition for seas=1, morph=1, sourc
#
0 #_Nblock_Patterns
#_Cond 0 #_blocks_per_pattern
# begin and end years of blocks
#
0.5 #_fracfemale
0 #_natM_type:_0=1Parm; 1=N_breakpoints;_2=Lorenzen;_3=agespecific;_4=ag
  #_no additional input for selected M option; read 1P per morph
1 #_GrowthModel: 1=vonBert with L1&L2; 2=Richards with L1&L2; 3=not impl
0 #_Growth_Age_for_L1
25 #_Growth_Age_for_L2 (999 to use as Linf)
0 #_SD_add_to_LAA (set to 0.1 for SS2 V1.x compatibility)
0 #_CV_Growth_Pattern:  0 CV=f(LAA); 1 CV=F(A); 2 SD=F(LAA); 3 SD=F(A);
1 #_maturity_option:   1=length logistic; 2=age logistic; 3=read age-
```

DATA

- Yearly or quarterly data
- Area definition
- Fishery

- Catch (by fishery, year, season)
- Abundance indices (ditto)
- Length composition
- Age composition
- Tag release/recovery data
- . . .

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DATA AND PROBABILITY DISTRIBUTION

Data ⇒ Prob distribution ⇒ Likelihood

＋ Constraints ＋ prior

- Catch
- CPUE
- Length composition
- Age-composition (or conditional age-at-length)

$$L = \sum_{i=1}^{I} \sum_{f=1}^{A_f} \omega_{i,f} L_{i,f} + \omega_R L_R + \sum_{\theta} \omega_\theta L_\theta + \sum_{P} \omega_P L_P \qquad (A.3.1)$$

Likelihood for data

Recruitment deviation

Prior

Time varying component

CATCH AND CPUE BY FISHERY

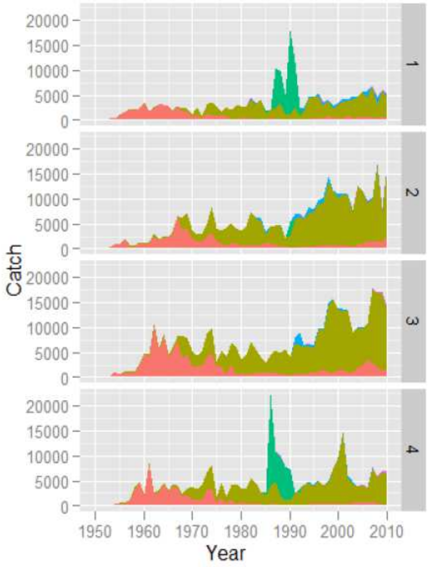
Fishery 1: Japanese longline(LL), including Korean and other countries Japan type longline (JPN_LL, 1952-2010)

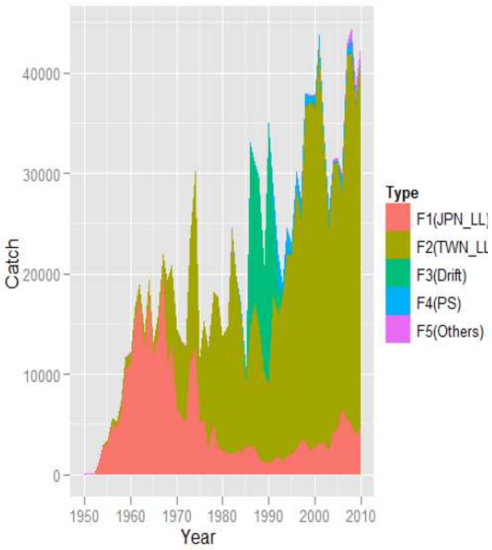
Fishery 2: Taiwanese longline, including Indonesian and other countries Taiwan type longline (TWN_LL, 1954-2010)

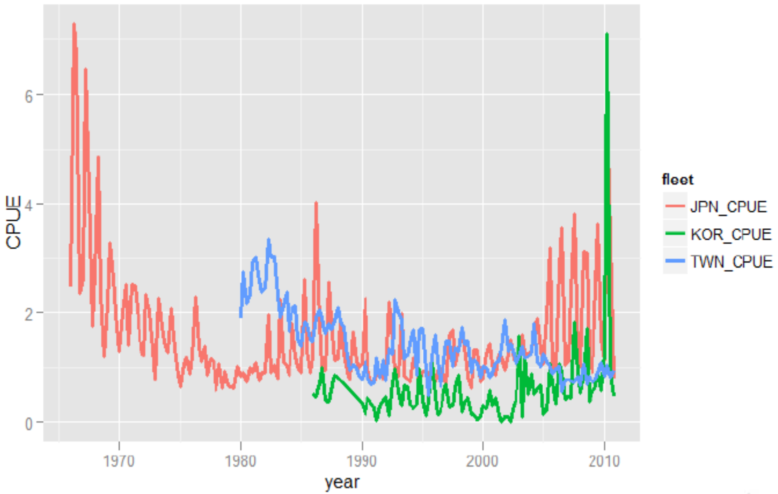
Fishery 3: Taiwanese Drift gill net (Drift, 1982-2010)

Fishery 4: Purse Seine (PS, 1982-2010)

Fishery 5: Others (Others, 1950-2010)







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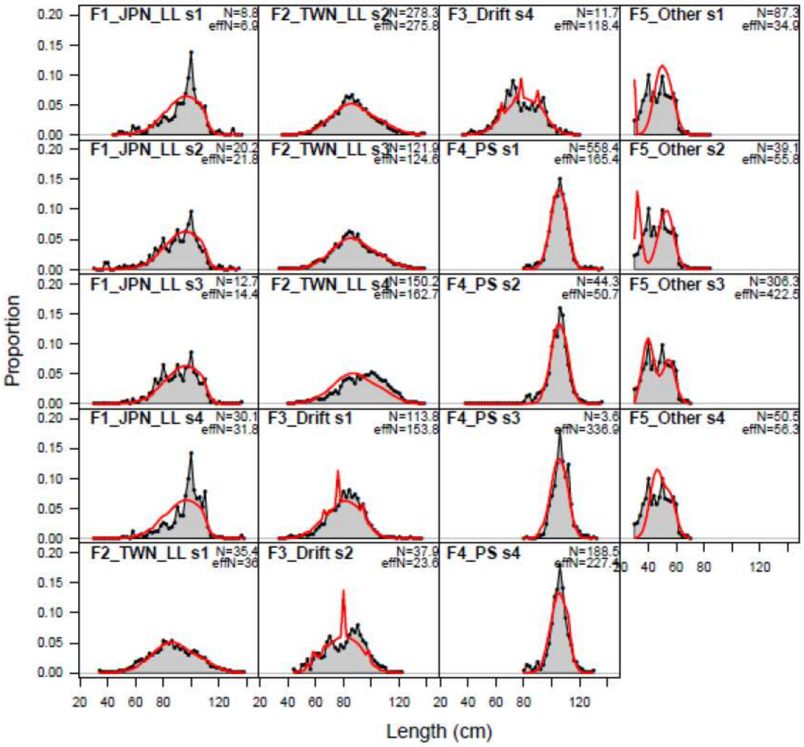
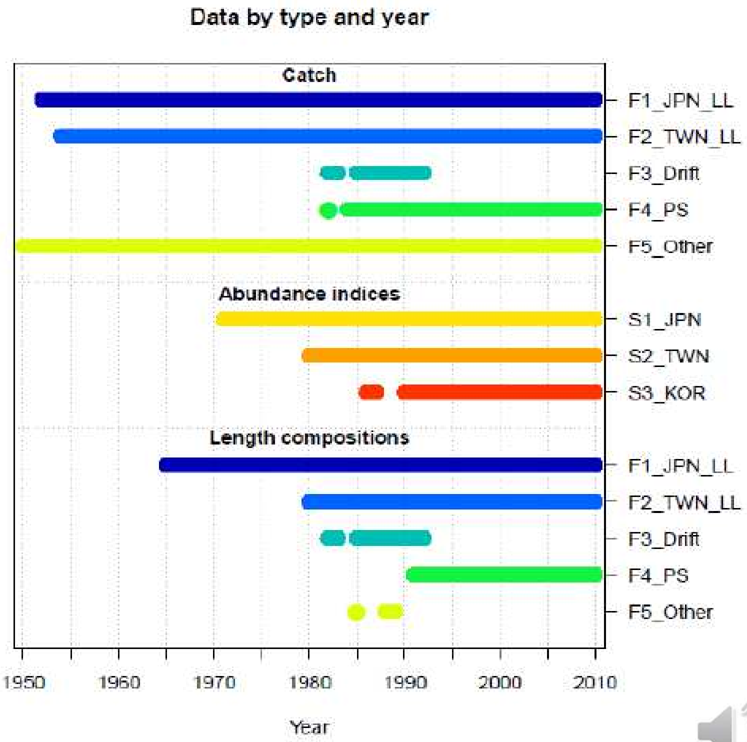
LENGTH DATA





DATA FILE

```
#C data file for simple example
1971 #_styr
2001 #_endyr
1 #_nseas
 12 #_months/season
1 #_spawn_seas
1 #_Nfleet
2 #_Nsurveys
1 #_N_areas
FISHERY1%SURVEY1%SURVEY2
 0.5 0.5 0.5 #_surveytiming_in_season
 1 1 1 #_area_assignments_for_each_fishery_and_survey
 1 #_units of catch:  1=bio; 2=num
 0.01 #_se of log(catch) only used for init_eq_catch and for Fmethod 2 and 3
2 #_Ngenders
40 #_Nages
 0 #_init_equil_catch_for_each_fishery
31 #_N_lines_of_catch_to_read
#_catch_biomass(mtons):_columns_are_fisheries,year,season
 0 1971 1
 200 1972 1
 1000 1973 1
 1000 1974 1
```

VERY QUICK OVERVIEW OF SS FRAMEWORK

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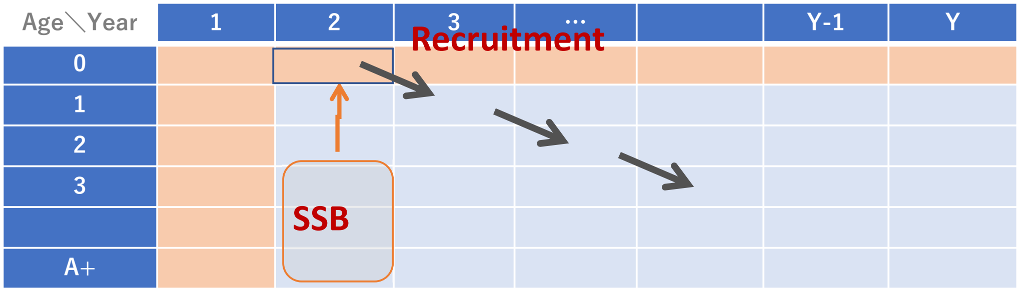
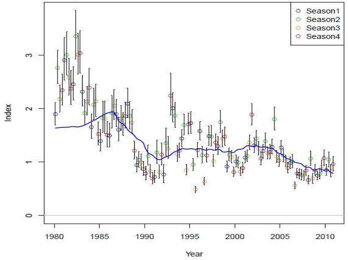
Age-structured pop dynamics

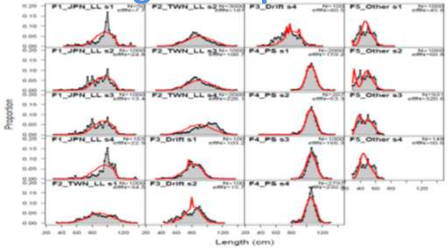


Typical data

CPUE



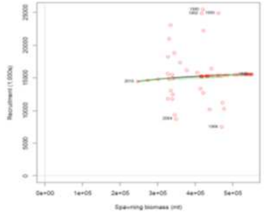
Length composition



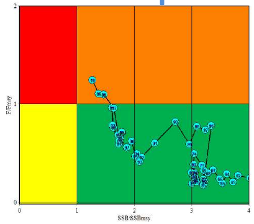
Some outputs

SSB

Spawner - Rec



KOBE plot



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TYPES OF METHODS FOR INFERRING POPULATION DYNAMICS

	Production model	Delay-difference model	Stage-based model	Age(size)-structured model
Age-structured?	Totally age-aggregated	2-stages (Juvenile & mature)	Like glass, yellow and silver etc.	Yes
Data (catch series)	Just total catch	• Catch for each stage or • Total catch (but need information on composition in some samples)	• Catch for each stage or • Total catch (but need information on composition in some samples)	• Catch for each age (or size) or • Total catch (but need information on composition in some samples)
Data (abundance indices)	CPUE series by fishery	CPUE series by stage and by fishery	Hopefully CPUE series by stage and fishery	CPUE series in total by fishery
Data (composition)	Not necessary	Needed by stage if only total catch is available	Needed by stage if only total catch is available	Needed by age/size if only total catch is available
Key biological parameters	Not specifically but rough idea of reasonable range of “r”	Growth and maturity (Recruitment structure is estimated internally)	Ditto	Ditto
Feasibility for eels	Not appropriate	Might be possible	Might be possible	Maybe in the future

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Stock Status of Indian Ocean Tuna

Stock	WP	2015	2016	2017	2018	2019	2020
Albacore	Temperate		SA			SA	
Bigeye tuna			SA			SA	
Skipjack tuna	Tropical			SA			SA
Yellowfin tuna		SA	SA		SA	SA	
Swordfish							SA
Black marlin			SA		SA		
Blue marlin	Billfishs		SA			SA	
Striped marlin		SA			SA		
Indo-Pacific Sailfish		SA				SA	
Bullet tuna							
Frigate tuna							
Kawakawa	Neritics	SA		SA			SA
Longtail tuna		SA	SA	SA			SA
Indo-Pacific king mackerel		SA	SA				SA
Narrow-barred Spanish mackerel		SA	SA	SA			
Blue shark				SA			
Oceanic whitetip shark							
Scalloped hammerhead shark							
Shortfin mako	Bycatch (shark)						SA
Silky shark							
Bigeye thresher shark							
Pelagic threshere shark							
Seabirds	Bycatch						
Marine mammals							
Seaturtles							

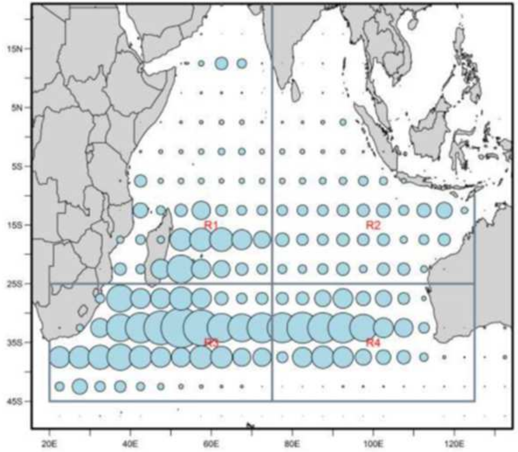
Report of the 22nd Session of IOTC Scientific Committee Karachi, Pakistan, 2-6 December 2019

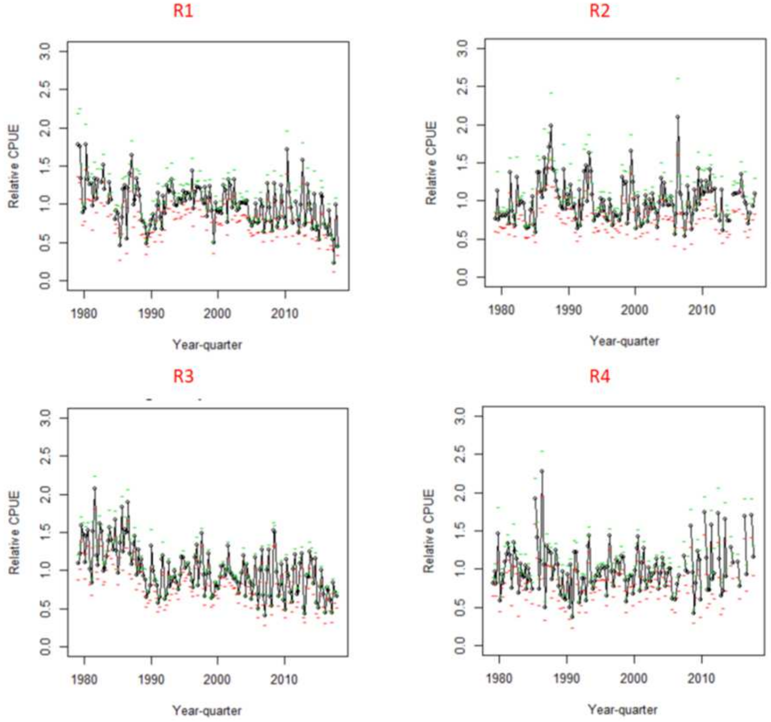
Toshihide Kitakado
(Tokyo Univ. Marine Science Technology)
Chair of the SC

2020 IOTC Commission Meeting, November 2-6, 2020

ALBACORE

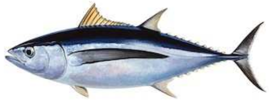
- Data preparation meeting in January 2019, in Kuala Lumpur, Malaysia
  - Catch series, Joint CPUE, size data, biological parameters, specification



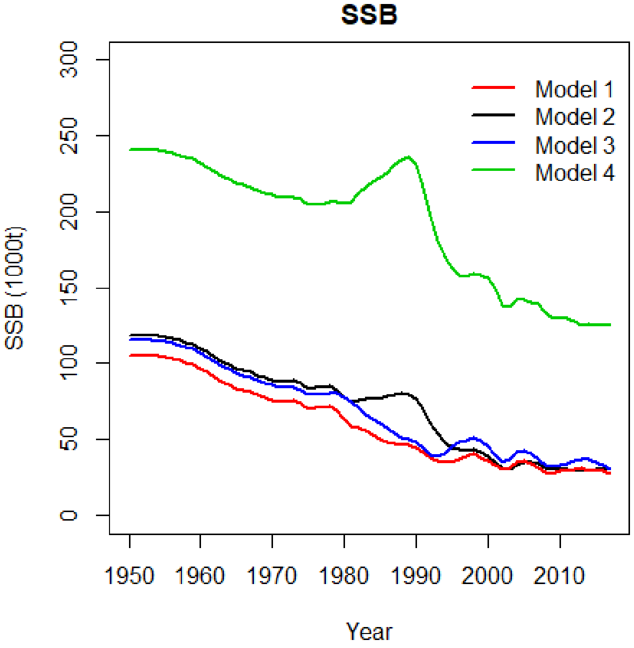


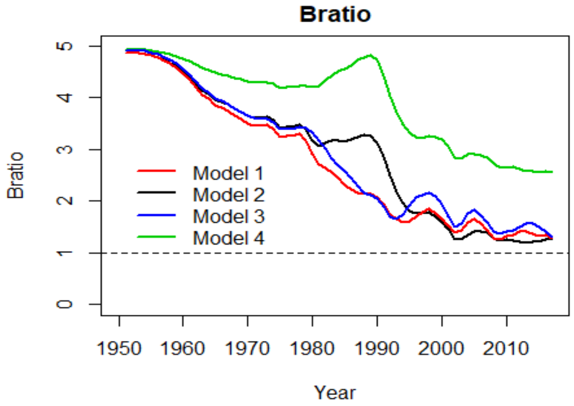
- Stock assessment meeting in July 2019 in Shimizu, Japan

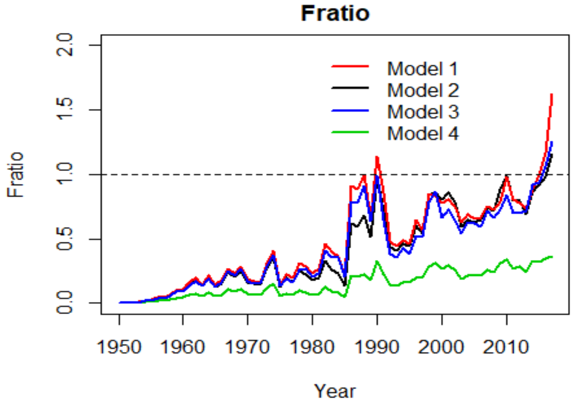
ALBACORE



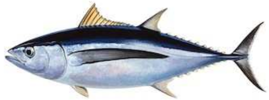
- Two types of assessment models were used
  - Bayesian state-space production models
  - Stock Synthesis 3 (SS3, used for advice this time)

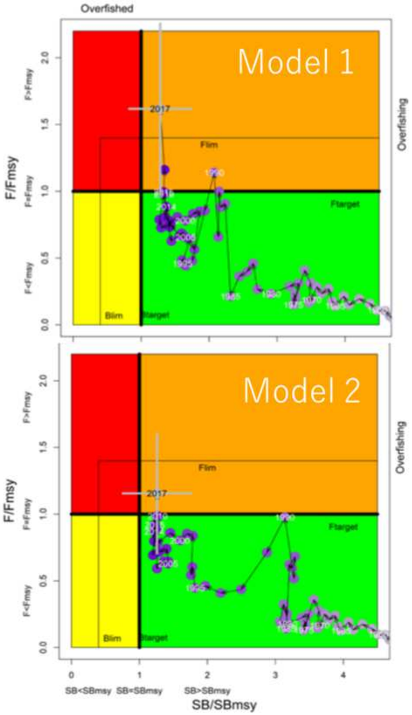
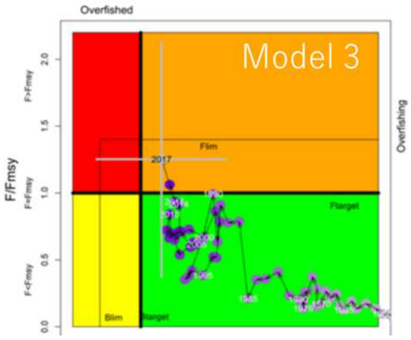


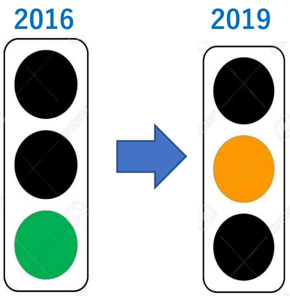




ALBACORE





Change from 2016 assessment to 2019 one

- The similar model was used, but catch and CPUE data were updated (CPUE were significantly different from 2016)
- CPUE in R1&R2, used in fitting, showed decreasing trends since 1979
- Different growth function was used
- Lower MSY and BMSY estimates were provided.

=> These can attribute to changes in the stock status

Indicators – 2019 assessment		2019 stock status[3] determination
	SS3	
Catch 2018[2]:	41,603 t	
Average catch 2014–2018:	38,030 t	
MSY (1000 t) (95% CI):	35.7 (27.3–44.4)	
F_{MSY} (95% CI):	0.21 (0.195-0.237)	
SB_{MSY} (1000 t) (95% CI):	23.2 (17.6–29.2)	
F_{2017}/F_{MSY} (95% CI):	1.346 (0.588–2.171)	
SB_{2017}/SB_{MSY} (95% CI):	1.281 (0.574–2.071)	
SB_{2017}/SB_{1950} (95% CI):	0.262 (-)	

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ALBACORE

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K2SM with respect to the target reference points (SB_{MSY} and F_{MSY})

Table 11. Albacore: SS3 aggregated Indian Ocean assessment Kobe II Strategy Matrix based on the model options (i) Model 1 (ii) Model 2 (iii) Model 3 . Probability (percentage) of violating the MSY-based target (top) and limit (bottom) reference points for constant catch projections (2017 catch level, ± 10%, ± 20%, ± 30% ± 40%) projected for 3 and 10 years.

Reference point and projection timeframe	Alternative catch projections (relative to the catch level for 2017) and probability (%) of violating MSY-based target reference points ($SB_{targ} = SB_{MSY}$; $F_{targ} = F_{MSY}$)								
	60% (22,901)	70% (26,718)	80% (30,534)	90% (34,351)	100% (38,168)	110% (41,985)	120% (45,802)	130% (49,618)	140% (53,435)
$SB_{2020} < SB_{MSY}$	0.614	0.678	0.715	0.769	0.818	0.828	0.87	0.883	0.898
$F_{2020} > F_{MSY}$	0.074	0.224	0.4	0.556	0.654	0.731	0.766	0.788	0.782
$SB_{2027} < SB_{MSY}$	0.176	0.307	0.456	0.572	0.713	0.823	0.898	1	1
$F_{2027} > F_{MSY}$	0.002	0.085	0.287	0.473	0.718	0.878	1	1	1

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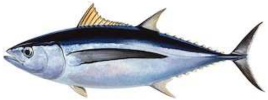
ALBACORE



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Stock status

- A new stock assessment was carried out for albacore in 2019 using Stock Synthesis III (SS3)
- The current assessment has utilized joint CPUE series that are significantly different from the last assessment. Catches have also increased substantially since 2007 for some fleets
- Fishing mortality represented as F2017/FMSY is 1.346 (95%CI=0.588–2.171). Biomass is estimated to be above the SBMSY level as B2017/BMSY =1.281 (95%CI=0.574–2.071). **The stock status in relation to the Commission's BMSY and FMSY target reference points indicates that the stock is not overfished but is subject to overfishing**

Outlook and Management Advice

- Maintaining or increasing effort in the core albacore fishing grounds is likely to result in further decline in the albacore tuna biomass, productivity and CPUE. Although considerable uncertainty remains in the assessment conducted in 2019, **current catches (38,168 t in 2017) are exceeding the estimated MSY level (35,700 t) and therefore a precautionary approach should be applied**
- **The K2SM indicates that catch reductions are required in order to prevent the biomass from declining to below MSY levels in the short term**

Food and Agriculture Organization of the United Nations

BIGEYE

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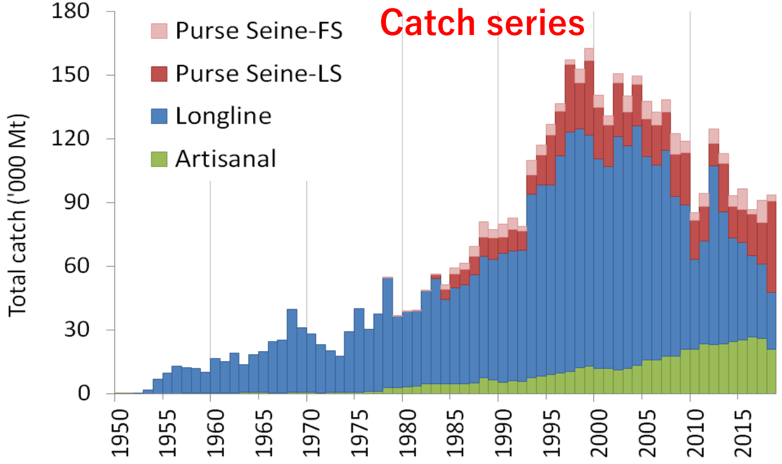
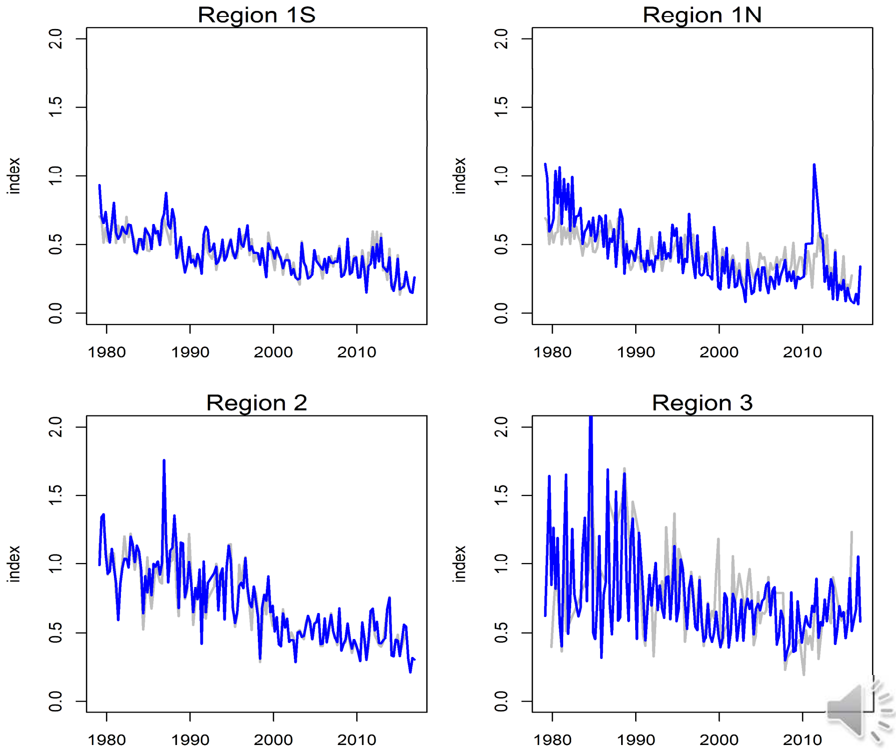
- Catch series
- Abundance index: Joint Longline CPUE
- Size frequency data
- Tagging data



Standardized CPUE series [continued decline]



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BIGEYE

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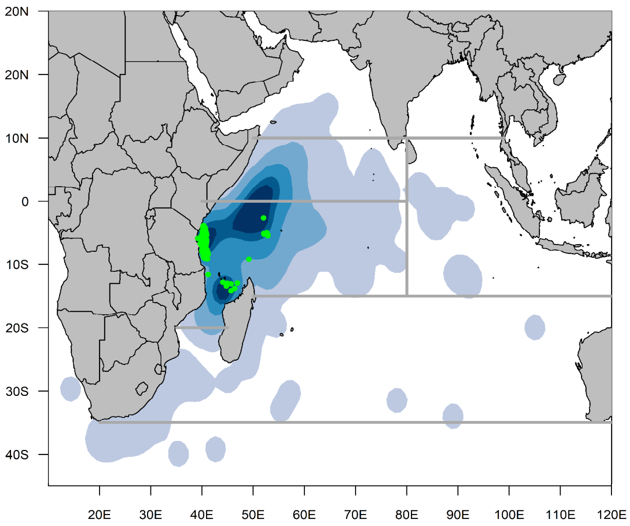
- Catch series
- Abundance index: Joint Longline CPUE
- Size frequency data
- Tagging data: release/recovery from Indian Ocean RTTP used with a tag-release mortality parameter that assumes a higher mortality (≠ 2016)



Two types of assessment models

- Bayesian state-space production models (JABBA)
- Stock Synthesis 3 (SS3, used for advice this time)

Structural uncertainty: SS3, grid of 18 model configurations that capture uncertainty on:

- Stock recruitment relationship (3 levels = 2016)
- Influence of tagging information (tag weight in the likelihood, 3 levels ≈ 2016)
- Selectivity of longline fleets (2 levels ≠ 2016)

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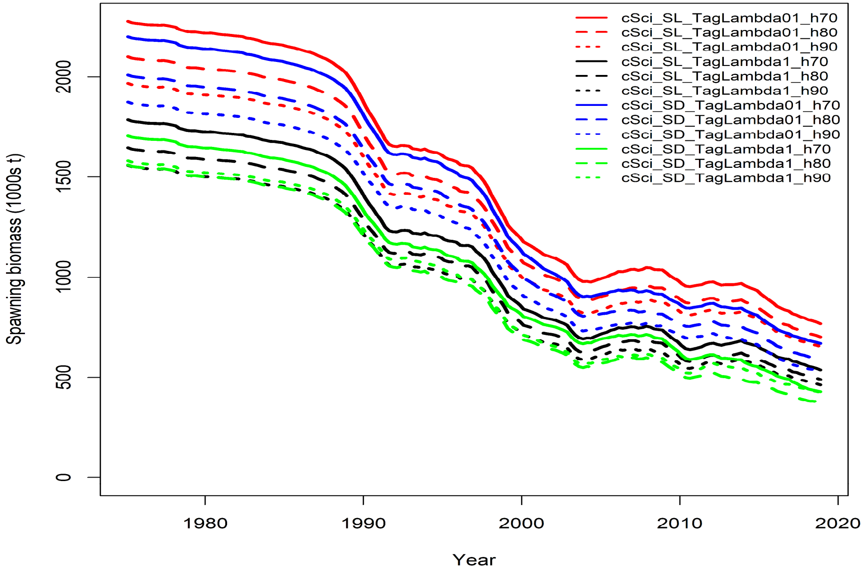
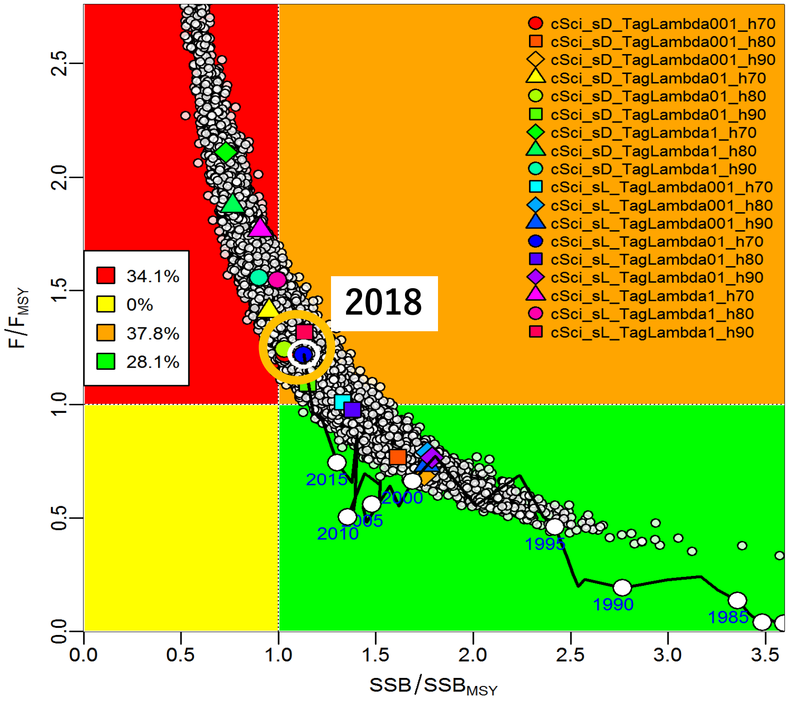

cSci_SL_TagLambda01_h70
cSci_SL_TagLambda01_h80
cSci_SL_TagLambda01_h90
cSci_SL_TagLambda1_h70
cSci_SL_TagLambda1_h80
cSci_SL_TagLambda1_h90
cSci_SD_TagLambda01_h70
cSci_SD_TagLambda01_h80
cSci_SD_TagLambda01_h90
cSci_SD_TagLambda1_h70
cSci_SD_TagLambda1_h80
cSci_SD_TagLambda1_h90
Spawning biomass (1000s t)
0
500
1000
1500
2000
1980
1990
2000
2010
2020
Year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cSci_sD_TagLambda01_h90
cSci_sD_TagLambda1_h70
cSci_sD_TagLambda1_h80
cSci_sD_TagLambda1_h90
cSci_sL_TagLambda001_h70
cSci_sL_TagLambda001_h80
cSci_sL_TagLambda001_h90
cSci_sL_TagLambda01_h70
cSci_sL_TagLambda01_h80
cSci_sL_TagLambda01_h90
cSci_sL_TagLambda1_h70
cSci_sL_TagLambda1_h80
cSci_sL_TagLambda1_h90
2018
34.1%
0%
37.8%
28.1%
2015
2010
2000
1995
1990
1985
F/F_{MSY}
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
SSB/SSB_{MSY}

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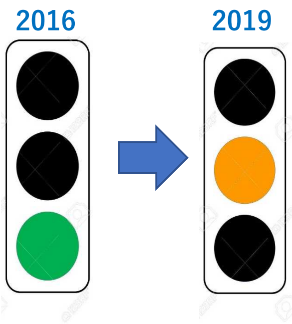
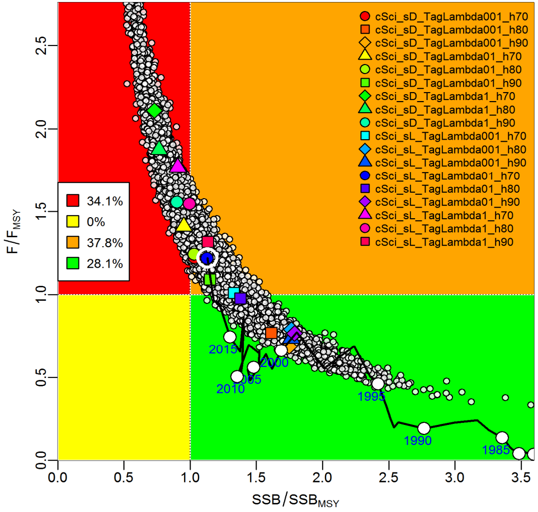


Main change from 2016 assessment to 2019 one

- Updated abundance index developed in 2019
- Recent increased fishing pressure on juvenile by PS
- Changes in model assumptions about LL selectivity
- Changes in tag release mortality

etc.



Area[1]	Indicators		2019 stock status[3] determination
Indian Ocean[5]	Catch in 2018[2]: Average catch 2014–2018:	93,515 t (81,413 t)[4] 92,140 t (89,720 t)[4]	38.2%*
	MSY (1,000 t) (80% CI): F_{MSY} (80% CI): SB_{MSY} (1,000 t) (80% CI): F_{2018}/F_{MSY} (80% CI): SB_{2018}/SB_{MSY} (80% CI): SB_{2018}/SB_0 (80% CI):	87 (75-108) 0.24 (0.18-0.36) 503 (370-748) 1.20 (0.70-2.05) 1.22 (0.82-1.81) 0.31 (0.21. – 0.34)	

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Reference point and projection timeframe	Alternative catch projections (relative to the catch level from 2018) and weighted probability (%) scenarios that violate reference point				
	60% (48,848t)	70% (56,990t)	80% (65,130t)	90% (73,272t)	100% (81,413t)
$B_{2021} < B_{MSY}$	51.1	53.3	54.2	57.1	58.9
$F_{2021} > F_{MSY}$	7.3	17.8	32	47.9	62.8
$B_{2028} < B_{MSY}$	8	19.5	35.1	49.1	60.8
$F_{2028} > F_{MSY}$	1.1	6.9	19.8	37.7	55.6

Reference point and projection timeframe	Alternative catch projections (relative to the catch level from 2018) and probability (%) of violating MSY-based limit reference points ($B_{lim} = 0.5\ B_{MSY}$; $F_{Lim} = 1.3\ F_{MSY}$)				
	60% (48,848t)	70% (56,990t)	80% (65,130t)	90% (73,272t)	100% (81,413t)
$B_{2021} < B_{LIM}$	0	0	0	0	0
$F_{2021} > F_{LIM}$	6.0	11.0	17.0	28.0	39.0
$B_{2028} < B_{LIM}$	0.0	0.0	6.0	11.0	22.0
$F_{2028} > F_{LIM}$	0.0	6.0	17.0	22.0	39.0

BIGEYE

Stock status

- A new stock assessment was carried out for bigeye tuna in 2019 using Stock Synthesis III (SS3) with a grid of 18 model configurations designed to capture the model uncertainty
- **The assessment outcome is qualitatively different to the stock assessment conducted in 2016.** Fishing mortality represented as F2018/FMSY is 1.20 (0.70–2.05). Biomass is estimated to be above the SBMSY level (B2018/BMSY =1.22 (0.82–1.81)) from the SS3 model
- The average catches over 2014-2018 (≈89,717 t) just above the estimated median MSY (87,000 t)
- **Thus, on the weight-of-evidence available in 2019, the bigeye tuna stock is determined to be not overfished but subject to overfishing**

Outlook and Management Advice

- If catches remain at current levels, there is a risk of breaching MSY reference points with 58.9% and 60.8% probability in 2021 and 2028. Reduced catches of at least 10% from current levels will likely reduce the probabilities of breaching reference levels to 49.1% in 2028
- Continued monitoring and improvement in data collection, reporting and analyses is required

SUMMARY OF STOCK STATUS

Stock	WP	2015	2016	2017	2018	2019	2020
Albacore	Temperate		SA			SA	
Bigeye tuna			SA			SA	
Skipjack tuna	Tropical			SA			SA
Yellowfin tuna		SA	SA		SA	SA	
Swordfish							SA
Black marlin			SA		SA		
Blue marlin	Billfishs		SA			SA	
Striped marlin		SA			SA		
Indo-Pacific Sailfish		SA				SA	
Bullet tuna							
Frigate tuna							
Kawakawa	Neritics	SA		SA			SA
Longtail tuna		SA	SA	SA			SA
Indo-Pacific king mackerel		SA	SA				SA
Narrow-barred Spanish mackerel		SA	SA	SA			
Blue shark				SA			
Oceanic whitetip shark							
Scalloped hammerhead shark							
Shortfin mako	Bycatch (shark)						SA
Silky shark							
Bigeye thresher shark							
Pelagic threshere shark							
Seabirds	Bycatch						
Marine mammals							
Seaturtles							

NEXT WEEK

- Online teaching materials will be provided at noon on Jan 19, 2021

https://toshihidekitakado.github.io/Kitakado_TUMSAT_Classes/tmp.html