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REPORT OF THE TRAINING AND CAPACITY BUILDING WORKSHOP OF THE CRFM CONTINENTAL SHELF FISHERIES WORKING GROUP (CRFM-CSWG): Data-limited Assessment of the Groundfish Stocks for Guyana, Suriname, and Trinidad and Tobago

31 March - 04 April 2025
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CRFM FISHERY REPORT – 2025/2

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LIST OF ACRONYMS AND ABBREVIATIONS

BRD	Bycatch Reduction Device
CPUE	Catch Per Unit Effort
CRFM	Caribbean Regional Fisheries Mechanism
CSWG	Continental Shelf Fisheries Working Group
EAF4SG	Enhancing capacity for the adoption and implementation of EAF (An Ecosystem Approach to Fisheries) in the shrimp and groundfish fisheries of the North Brazil Shelf Large Marine Ecosystem
FAO	Food and Agriculture Organization of the United Nations
FISH4ACP	Sustainable Development of Fisheries and Aquaculture Value Chains in African, Caribbean and Pacific (ACP) Countries
GUI	Graphical User Interface
HCR	Harvest Control Rule
HTML	Hypertext Markup Language
JABBA	Just Another Bayesian Biomass Assessment (R Package)
JAGS	Just Another Gibbs Sampler (Software library)
LB-SPR	Length Based – Spawning Potential Ratio (R Package)
MCMC	Markov Chain Monte Carlo
MSY	Maximum Sustainable Yield
REBYC-III	Strategies, technologies, and social solutions to manage bycatch in tropical Large Marine Ecosystem Fisheries
SPR	Spawning Potential Ratio
UWI	University of the West Indies
XML	Extensible Markup Language

1.0 INTRODUCTION & TRAINING OBJECTIVES

The Caribbean Regional Fisheries Mechanism Continental Shelf Fisheries Working Group (CRFM-CSWG) convened a training and capacity-building workshop on Data-limited Assessment of the Groundfish Stocks of Guyana, Suriname, and Trinidad and Tobago, in Paramaribo, Suriname, from 31 March to 04 April 2025. The event was held in collaboration with the EAF4SG Project (Enhancing capacity for the adoption and implementation of EAF (An Ecosystem Approach to Fisheries) in the shrimp and groundfish fisheries of the North Brazil Shelf Large Marine Ecosystem), the FISH4ACP Project (Sustainable Development of Fisheries and Aquaculture Value Chains in African, Caribbean and Pacific Countries), the Fisheries Department of Suriname, the Fisheries Department of Guyana, and the Fisheries Division of Trinidad and Tobago.

The specific objectives of the training workshop were to:

- Review and clean groundfish data for Guyana and Suriname;
- Enhance stock assessment knowledge among data managers from Guyana, Suriname, and Trinidad and Tobago;
- Apply data-limited software tools in R for stock assessment, focusing on at least one groundfish species per country; and
- Improve groundfish data collection methods for Trinidad and Tobago for stock assessment.

The training workshop was attended by officers from the Fisheries Department of Guyana (who participated online), the Fisheries Department of Suriname, and the Fisheries Division of Trinidad and Tobago, as well as representatives of the EAF4SG and FISH4ACP projects and the CRFM Secretariat. The training workshop was facilitated by Dr. Paul Medley, Independent Fisheries Stock Assessment Consultant, and Dr. Tomas Willems, Head of Research and Statistics, Suriname Fisheries Department. The list of participants is given at ***Appendix 1***. The agenda is given at ***Appendix 2***.

2.0 METHODOLOGY

The aim of the workshop was to expose participants to stock assessment methods and techniques to enhance their capacity to conduct stock assessments of their groundfish stocks using data-limited software tools. The methodology included:

- Preparatory activities:
  - Separate preparatory meetings were convened online with Guyana, Suriname, and Trinidad and Tobago to discuss the data requirements for the stock assessment and to assess the condition of the datasets for analysis. The preparatory sessions focused on: data availability, data preparation and data format requirements for the stock assessment workshop; and length-based catch curve and state-space production model (as appropriate per country).
  - Preparation of workshop material – Sample datasets, templates, and instructions prepared by facilitators were shared via Google Drive.
- Training activities:
  - Lectures on fundamental principles in stock assessment and selected stock assessment methods and their application.
  - Practical group sessions: Small groups assessed selected groundfish species using national datasets.
  - Observation: Field trip to observe activities at a processing plant.
  - Plenary presentation of results and discussion.

3.0 OPENING CEREMONY

The meeting was called to order at 9:10 a.m. on 31 March 2025. It commenced with a short opening ceremony chaired by Mrs. Nerissa Lucky, Technical Project Coordinator, EAF4SG Project. Dr. Sandra Grant, Acting Executive Director, CRFM Secretariat; Dr. Marcelo Vasconcellos, Fishery Resources Officer, FAO; Ms. Dawn Maison, Technical Specialist, FISH4ACP Project; Mr. Zojindra Arjune, Deputy Director of Fisheries, Suriname; and Dr. Tomas Willems, Head of Research and Statistics, Suriname Fisheries Department, delivered brief remarks. The available remarks are given at ***Appendix 3***.

The Chairperson gave a warm welcome to all the training workshop participants. She stated that the EAF4SG Project encourages the adoption of holistic, inclusive fisheries management approaches that consider the entire ecosystem, to promote sustainable and resilient shrimp and groundfish fisheries in the target countries of Guyana, Suriname, and Trinidad and Tobago. The Chairperson noted the collaboration between the EAF4SG Project, the CRFM-CSWG, and the FISH4ACP Project and expressed the hope that this partnership would be strengthened to build synergies with other regional partners in the future. In closing, the Chairperson wished participants an interactive and beneficial training workshop and thanked the Fisheries Department of Suriname for coordinating in-country logistics and for hosting the workshop.

In her address, the CRFM Secretariat's ***Acting Executive Director***, ***Dr. Sandra Grant***, said that the CRFM-CSWG seeks to foster the sustainable use of continental shelf resources and their associated ecosystems, through the review and analysis of fisheries and related data and the development of appropriate management strategies. She highlighted the economic and social importance of the groundfish resources in Guyana, Suriname, and Trinidad and Tobago, and the need for a comprehensive groundfish stock assessment program to assist these countries with sustainably managing the fisheries. Dr. Grant spoke of the CRFM Secretariat's commitment to capacity building in fish stock assessments for Member States through collaboration with various academic institutions, as well as through the CRFM Data Assessment Network. Dr. Grant extended a warm welcome to partners from FAO, (UWI/EAF4SG, and FISH4ACP) and noted the need for a collective effort in addressing the challenges of sustainable fisheries management.

The FAO Fishery Resources Officer, Dr. Marcelo Vasconcellos, highlighted the collaborative spirit of the EAF4SG Project, which aims to strengthen countries' capacity to manage the shared shrimp and groundfish resources of the North Brazil Shelf Large Marine Ecosystem. He also expressed gratitude for the active cooperation among participating countries, the CRFM, and the EAF4SG team in organizing the workshop. He reminded participants that a key component of the project focuses on enhancing the information available for fisheries management. By the end of the project, new and updated stock assessments for shrimp and groundfish stocks are expected, and this workshop represents an important step toward that goal. He noted that beyond delivering new stock assessments, the project aims to build regional capacity for conducting stock assessments in the future. He emphasized that this workshop would be followed by similar activities to ensure the achievement of the project's expected outcomes. In closing, he thanked the host country and extended his best wishes for a successful workshop.

Ms. Dawn Maison, Technical Specialist, FISH4ACP Project-Guyana, said that FISH4ACP is dedicated to enhancing the productivity and sustainability of fisheries and aquaculture value chains. In Guyana, the aim is to foster inclusive and resilient growth, with specific focus on the seabob value chain. A core focus is fostering behavioural changes that promote sustainability through responsible fishing practices, reduced post-harvest losses, and enhanced stewardship. Ms. Maison acknowledged the importance of improved data management and robust stock assessments to enable more accurate predictions of stock status and to facilitate adjustments to fishing practices. Like previous speakers, Ms. Maison too emphasized the need for continued collaboration with regional partners, such as CRFM, and projects, such as the EAF4SG Project.

Mr. Zojindra Arjune, Deputy Director of Fisheries, Suriname, on behalf of the Ministry of Agriculture, Animal Husbandry and Fisheries and the Fisheries Department, extended a warm welcome to all. Mr. Arjune agreed with the sentiments expressed by previous speakers regarding the importance of stock assessments for responsible stewardship of the fisheries resources, and the need for continued collaboration among regional partners and projects in the management of shared ocean resources. He expressed appreciation for the efforts of the Department's staff in terms of collection, analysis, and interpretation of the data, and provision of advice to inform fisheries management decisions. In concluding, Mr. Arjune referred to the demands from market states for science-based evidence and decisions, which align with the objectives of this workshop, and wished the gathering fruitful discussions.

Dr. Tomas Willems, Head of Research and Statistics Unit, Suriname Fisheries Department, said the focus of the workshop was capacity-building, with three specific objectives:

- Firstly, recognizing that participants had varying levels of training and/or exposure to stock assessments, it sought to ensure that all participants understood the stock assessment process, as stock assessment practitioners should be able to understand and explain the outputs of the assessments and provide management advice.
- Secondly, it sought to introduce participants to modern stock assessment tools, specifically R (open-source programming language used for programming, data analysis and data visualization), and RStudio (Graphical User Interface (GUI) for R).
- Finally, using national data, it attempted to conduct stock assessments of selected groundfish species, using R and RStudio and data-limited stock assessment methods.

Dr. Willems remarked that while officers will not return to their capitals with finalized stock assessments and definitive results on the status of stocks, they should have a deeper understanding of the process and be able to identify weaknesses and propose solutions. In closing, he expressed hope that the three objectives outlined will be achieved and that the workshop would be a success.

4.0 INTRODUCTION TO FISH STOCK ASSESSMENT

Dr. Tomas Willems presented this agenda item. The presentation commenced with a comprehensive explanation of the multi-step stock assessment process from management questions and data collection through to interpretation of assessment results and generation of management advice. Carrying capacity and its role in the dynamics of exploited fish populations, including determination of safe harvest rates and balancing short-run catches against possible changes in the long-run biological productivity, was also highlighted. The additive (growth and recruitment) and subtractive (fishing mortality and natural mortality) processes that influence fluctuations in stock status over time, as well as the elements involved, and calculation of Maximum Sustainable Yield (MSY) were expounded. Management options based on catch or fishing pressure or biomass were indicated. The presentation concluded with an example of Effort Management in the Guyana/Suriname seabob fishery using a Harvest Control Rule (HCR). The presentation is given at ***Appendix 4***.

Discussion

The frequency of revision of the HCR index and implementation of the HCR were discussed. The HCR index for Suriname was updated every month based on data provided by the fishery for the previous month. The HCR index was discussed at the monthly Seabob Working Group meeting, and the fishing effort (days-at-sea) for the following month was set; a two-month lag. The HCR index was based on historical information and novel circumstances could result in a poor fit. Most HCRs included *special circumstances clauses* that, in collaboration with stakeholders (in this case the Seabob Working Group), allowed for the HCR to be adjusted with justification. Additionally, the HCR was testable through simulation, which showed that the rule worked with the interpretation of the data (the model). The HCR, including special circumstances clauses that provide flexibility to adjust to unexpected events, was an important component of a management strategy that was consistent with observed trends and adaptive to uncertainties.

The effort management example was referred, and a query raised as to whether a single assessment was conducted for the Guyana and Suriname seabob fishery. It was noted that based on the stock hypothesis of separate stocks, separate assessments were conducted for Suriname and Guyana. However, both fisheries were managed using similar HCR systems.

5.0 INTRODUCTION TO DATA-LIMITED MODELS

This agenda item was presented by Dr. Paul Medley, Independent Fisheries Stock Assessment Consultant. Dr. Medley indicated that the focus would be on two methods, specifically catch-based and length-based models, which had application based on available data.

5.1 Catch-based Models (JABBA)

Dr. Medley delivered a PowerPoint presentation titled: *JABBA: State Space Production Models.* A brief explanation of general depletion models – a basic depletion model with an example – was given. Production models, including the Pella-Tomlinson and the Schaefer models, were introduced. The Schaefer model, which was used in the training, was explained and included information on the yield curve, sources of uncertainty, setting of management controls, fitting data, and model fitting. The use of *priors* or *penalties* to include external information, improve model fit, and reduce uncertainty was also highlighted. The importance of timeseries data, which provide a record of changes in fish populations over time, to model fit and generation of management advice was noted. Process error was defined and the significant impact this source of error could have on the reliability of assessment results and management decisions was highlighted. An example of process error and how it is described in state-space models was given as a Markov Process[1]. Bayesian statistics offer good solutions for dealing with observation and process errors but require methods that are able to “integrate out” the uncertainty. The main technique, among modern methods, is the Markov Chain Monte Carlo (MCMC)[2] technique, which was briefly explained. MCMC is a form of Monte Carlo integration[3] which was illustrated using a simple example. The MCMC algorithm used by the state-space production model JABBA (Just Another Bayesian Biomass Assessment) is JAGS (Just Another Gibbs Sampler), which required installation. The presentation concluded with an argument for the standardization of Catch Per Unit Effort (CPUE), although this was not pursued further in this training workshop. The presentation is given at ***Appendix 5***.

After the presentation, the workshop facilitators assisted participants, who had not yet done so, to download the relevant software packages and programs that would be required for the practical sessions. These included R, RStudio and RTools, JAGS library, JABBA, and fishblicc.

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[1] *Markov process is a stochastic process where the future states only depend on the current state and not on the past states. It is fully determined by functions that describe the probabilities of transitioning between states.*
[2] *Markov Chain Monte Carlo (MCMC) is a class of algorithms used to draw samples from a probability distribution.*
[3] *Monte Carlo integration is a technique for numerical integration using random numbers and includes MCMC.*

5.1.1 Practical session using JABBA

Following a brief recap of the key concepts shared in the presentations on Introduction to Stock Assessments, and Catch-based Models (JABBA), Dr. Medley facilitated a practical session. For this exercise, participants were expected to run a JABBA assessment using a simulated dataset provided by the facilitator. Dr. Medley projected his screen and went through the JABBA assessment process step by step and gave instructions which participants were expected to follow. He simultaneously executed the commands himself and provided explanations of each step so that participants could see the output each command yielded. Dr. Medley, with assistance from Dr. Willems, answered participants' questions and assisted them with addressing any errors they encountered when they executed functions in the software. A sample of the outputs/results generated from the exercise is given at ***Appendix 6.***

5.2 Length-based assessment (fishblicc)

In his presentation titled: *A Length-based Catch Curve for Multigear Fisheries*, Dr. Medley noted that use of all length frequency data, Bayesian fitting, and flexible selectivity functions and multiple gears was the motivation for using a length-based catch curve where there was not a complete timeseries of length data. The assumptions for catch curves were enumerated, and two key assumptions were highlighted: (i) the population must be in a steady state for at least a generation; and (ii) length data were representative of the catch. A description of the model, which included relevant equations and worked examples, was given. The R package fishblicc[4] was introduced. The package implements Bayesian length-based catch curves and selectivity models based on simple mixtures of logistic, normal, single-sided normal, and double-sided normal distribution. The main outputs from fishblicc were the Spawning Potential Ratio (SPR) expressed as a percentage, and the selectivity at length. Simulation testing was demonstrated, and an illustrative example using the Indian Ocean Yellowfin Tuna was shown. The presentation is given at ***Appendix 7***.

5.2.1 Practical session using fishblicc

After the presentation, Dr. Medley facilitated a practical exercise in which participants were expected to run fishblicc. Dr. Medley projected his screen and simultaneously narrated and executed the various commands to run fishblicc. Dr. Willems assisted participants to address any errors they encountered when they executed functions in the software and answered queries. A sample of the outputs/results generated from the exercise is given at ***Appendix 8***.

5.2.2 Spawning Potential Ratio (SPR)

As part of his recap of the previous day's activities, which included presentations on catch-based (JABBA) and length-based (fishblicc) models, Dr. Willems gave a presentation on Spawning Potential Ratio (SPR), which was a key output of the length-based model (fishblicc). The SPR was the ratio comparing a situation where fishing was occurring to a hypothetical situation where there was no fishing. Hence, the value of SPR ranged from 0% (population with no egg production) to 100% (unfished population). Replacement level (recruitment ≥ to natural mortality + fishing mortality) was explained, and internationally accepted SPR values corresponding to reference points used by conventional stock assessment methods including - limit reference point (20% SPR); sustainable removal of fish - MSY (40% SPR); rebuild population (60% SPR) - were shared. In concluding, Dr. Willems said that the SPR, although it did not give an actual value of MSY, was a useful and relevant indicator to assess stock health. The presentation is given at ***Appendix 9***.

The CSWG was advised that the Guyana participants who participated online had experienced internet and other technical challenges the day before which hindered download of the relevant software packages

[4] *Fishblicc is an R package used for fitting Bayesian length interval catch curve models to length frequency samples.*

to enable them to do the practical exercises in JABBA and fishblicc. Following some discussion about how to best address the Guyana situation, mindful of the time constraints, it was agreed that arrangements would be made for Dr. Willems to conduct the training with the Guyana representatives, either electronically or in-person. It was also agreed that the Guyana participants will give a presentation at the plenary session the following afternoon on Guyana's fisheries data collection system, including challenges.

6.0 INTRODUCTION TO QUARTO IN R AND RSTUDIO

6.1 Data preparation and model selection (working groups per country)

The facilitators pointed participants to the Excel spreadsheets in the data subdirectory that had been shared with them, and advised that participants should ensure that their data followed that same format, which will then be used to run the assessments. The facilitators also provided assistance to participants, where requested, to reorganize data into the right format in R and adapt the template to analyse their own data. It was noted that Trinidad and Tobago had data to do a production model assessment in JABBA; while Suriname had only length data for several different groundfish species. Participants worked in small groups to conduct the assessments. A total of five preliminary assessments were attempted—three using data from Suriname and two with data from Trinidad and Tobago.

6.2 Reviewing input parameters for the assessed species

Dr. Willems presented this agenda item. He began his presentation with a brief description of Quarto, which is a software built to be compatible with RStudio and which is useful for reporting. Dr. Willems then shared his screen, which showed the RStudio environment and demonstrated how to open a Quarto document and set up the header, which included the document title, the editor, and the format of the document required. HTML was the default format, but documents could also be produced in Microsoft Word or PDF formats. PowerPoint presentations could also be created using Quarto. Major advantages of Quarto were: (i) content and executable code could be woven together into a finished document; and (ii) reports, once set-up, were reproducible (e.g., periodic reports utilizing similar methodology/format, but with updated data could be run very quickly). The use of the hashtag, which denotes a title or sub-title, as well as the editor options – source and visual, were highlighted. The use of '*code chunks*' (pieces of R code) to include tables, graphs, etc., in documents was expounded. Pictures and graphics from other sources can also be inserted into the document. Using the 'Render' button, the completed document was sent to Knitr[5], which executed all of the code chunks (R code) and produced the finished report. It was reiterated that once the code for a stock assessment was set up in Quarto, new data and information could be added or datasets changed and updated reports generated. Several tutorials and YouTube videos on Quarto are available online, and participants could access them for further details and practice.

6.2.1 Discussion

The ease of transition from R Markdown to Quarto, given their similarities, was discussed, and it was noted that switching to Quarto should be straightforward since a lot of the R Markdown code worked the same in Quarto. However, there are some nuanced differences that make Quarto better: it is more flexible, has greater functionality, and development would be limited to Quarto in the future.

[5] *Knitr is a software engine used to generate reports in Quarto, by integrating R code into documents. The mix of code, results, and text allows for the creation of dynamic, reproducible reports in different formats, such as, HTML, PDF, and Word.*

Queries were raised regarding generation of the report in Quarto in HTML format as opposed to XML. It was noted that XML is another markup language, but there is no connection between XML and Quarto. It was acknowledged that XML was often used as a way to store structured data.

7.0 SHARING MODEL RESULTS, EXCHANGE AND LESSONS LEARNED

7.1 Guyana Fisheries Data Collection and Challenges

A PowerPoint presentation titled, *Guyana Fisheries Data Collection and Challenges: An Overview of Methods, Data Sources, and Key Issues*, was delivered by Mr. Kadeem Jacobs, Fisheries Officer, Guyana Fisheries Department. A summary of the presentation is given below and the slides are included in ***Appendix 10***.

Guyana's fisheries are divided into three categories: marine fishery, freshwater inland fishery, and aquaculture. The marine fishery sector is further subdivided into the industrial fishery (seabob and prawn vessels), the semi-industrial fishery (red snapper and longline vessels), and the artisanal fishery. The collection of fisheries data is vital for sustainable management practices, biodiversity conservation, and policy making. Catch data, effort data, as well as biological data (length frequency data) are collected. Prior to 2020, Microsoft Excel was used for data storage, with only catch by species data and effort inputted. In 2021, a transition to a Microsoft Access Database was made as this database allowed for the storage of not just catch and effort but all the data recorded by the data collectors, including climate conditions, water colour, etc. In 2025, a new database system, Calipseo (run by FAO) that had greater capacity and functionality was adopted. The Fisheries Department faced several challenges in the collection of fisheries data, particularly from the artisanal fishery sector, including inadequate cooperation during data collection, access to artisanal fishing communities, and seasonal variability. Several approaches to address these constraints were being used, including annual training for the artisanal sector and the industrial sector.

7.1.1 Discussion

The discussion following the presentation focused on the challenges to data collection, including collecting data from the artisanal fisheries, and the approaches/interventions/programs utilized by the Guyana Fisheries Department to address these constraints to data collection. The Fisheries Department conducted annual training workshops in the various regions with the artisanal fishers. During these workshops, the importance of fisheries data collection to the long-term sustainable management of the fisheries resources and the role of fishers in the process were emphasized. While the Fisheries Department has engaged in educational outreach over the last 3 to 4 years, more outreach and public awareness is needed, especially in the remote regions where some artisanal fishers operate, as the apparent misconceptions about the role and responsibilities of the Fisheries Department and fishers in the fisheries management process persisted. The lack of enforcement in the data collection process was identified as a shortcoming that, if addressed, would help to improve data collection activities.

7.2 Preliminary assessment of the Acoupa weakfish (*Cynoscion acoupa*) fishery of Suriname

The assessment was conducted in fishblicc, using length frequency data for the Acoupa weakfish (*Cynoscion acoupa*), locally called 'Bang Bang', collected over the period 2022 to February 2025 from the driftnet fishery. The maximum length of the Acoupa weakfish is 125 cm and the asymptotic length is 128.9 cm. The growth rate (K) is 0.270 and the M / K is around 0.74. For the assessment, length bins of 5 cm were used, as there were more than 10,000 length observations. The assessment results were shared and the SPR was estimated to be 89%.

7.2.1 CSWG Evaluation of Acoupa weakfish (*Cynoscion acoupa*) assessment

- The graph displaying the normal distribution selectivity showed very low fishing mortality. Dome-shaped selectivity seemed appropriate for gillnet, but the very high SPR estimates should be treated with some skepticism and may not have been well estimated. Alternative assumptions should be evaluated where possible.
- It was suggested that instead of 5 cm bins, 2 cm bins could be used as it did not appear that the fish were being measured to 1 cm precision, as evidenced by the repeated low-high fluctuations, but there were a large number of observations. Going forward, perhaps fewer fish could be measured, but each fish in the smaller sample could be more precisely measured. The observation error was very high, so reducing the bin size could improve estimates. In addition to changing the bin width to 2 cm, the data could also be broken up into different time periods (for example, months, quarters, years).
- Although the SPR may not necessarily be well-estimated, given the size at which the fish were being caught, it was reasonable to conclude that the stock was not overfished. However, in the absence of more historical data, it was also possible that the situation was less optimistic and the fishery was fully exploited.
- The MCMC parameter estimates appeared to show the model was re-estimating L-infinity (asymptotic length growth parameter) towards the upper end of the frequency. The data affects the parameters, and the individual MCMC draws were spread between the two dotted lines for the L-infinity and reflected the prior. The L-infinity, the G-alpha (growth variability), and the M/K parameters were usually just dependent on the prior. In contrast, the selectivity parameters were well estimated.
- The value for L-infinity prior mean was much larger than the maximum posterior density estimate (128 cm vs 106 cm), and it was suggested that perhaps this was the reason for the high SPR. It was explained that a higher estimated L-infinity usually drove the stock status down quite dramatically. The model seemed to be favouring a smaller L-infinity, which could be addressed by putting in a sensitivity (e.g., a tighter prior on the higher L-infinity) that forces it to be a particular value rather than allowing the value to be estimated. The Bayesian model produces a spawning potential ratio as a probability density function to which more probability could be added to capture that uncertainty and possibly direct research to reduce some of the uncertainty.

7.3 Preliminary assessment of the Barracuda (*Sphyraena guachancho*) fishery of Suriname

The Barracuda (*Sphyraena guachancho*) caught in the bottom trawl was assessed using length frequency data collected by fisheries observers at the industrial landing sites over the period 2022 to February 2025. The maximum recorded length for the species is 200 cm, but lengths of 50 – 100 cm were more commonly encountered. For Suriname, the maximum length was 68 cm, and the L-infinity is 71.4 cm. In terms of results, the MCMC parameters estimated with the active sample size yielded L-infinity of 59.14 and an SPR of 43%. The length value of 59 was considered a low, and the assessment was highly uncertain. The fishery was estimated to be at the SPR MSY level.

7.3.1 CSWG Evaluation of Barracuda (*Sphyraena guachancho*) assessment

- Recorded lengths for this species went up to 200 cm, which suggested that L-infinity was higher than was estimated. It was clarified that based on the data, the length infinity was thought to be about 70 cm. The L-infinity of 70 cm was accepted, but it was noted that this was a key uncertainty.
- The initial maximum posterior density estimation did not fit the observations well. The report on the outputs stated "optimization terminated with error; line search failed." Despite that, the MCMC worked, and there was marked improvement in the fit with the MCMC. This fit could possibly be further improved by tightening up certain parameters and changing the priors manually.

- Additionally, if the L-infinity was kept close to what was thought to be the likely value (70 cm), then the SPR was not unreasonable as an estimate. This suggested making the prior more informative. Different selectivity functions could be tried and the data could be grouped in different ways.
- It was suggested that more data and information on the biology of the species was needed. Barracuda is an important species for the trawl fishery, although it is known to be more of a pelagic species; so it could be that juveniles, which might be schooling and tending to the bottom, were being captured. Further study of Barracuda, including size at maturity to determine whether juveniles or mature fish were being caught, is needed as it is an important species in terms of tonnage and marketing in Suriname.

7.4 Preliminary assessment of the White Salmon (*Cynoscion leiarchus*) fishery of Trinidad

The assessment of the white salmon (*Cynoscion leiarchus*) was conducted using fishblicc and length frequency data from the artisanal and non-artisanal shrimp trawl fisheries, collected by onboard observers over the period 2018-2023. Lengths of marketable fish, as well as the lengths of discards, were recorded. The model gave a reasonable fit to the observed data; the maximum posterior density fit assumed mixed selectivity, constant natural mortality, and logistic trawl selectivity. The fishblicc assessment results indicated that SPR was around 4.9%. The SPR of ~5% indicated very low spawning biomass and high fishing pressure.

7.4.1 CSWG Evaluation of the White Salmon (*Cynoscion leiarchus*) assessment

- The model appeared to fit the data quite well, but the SPR of approximately 5% seemed questionable. White salmon was also caught in the gillnet fishery (target fishery), but data from that fishery were not available, so the SPR would not be a valid estimate. It was, therefore, suggested that complete information across the other gears is needed. Additionally, the data collection (length frequency data for marketable fish as well as discards) from the trawl fishery, if continued, could provide the basis upon which a model could be built to explain status of the fishery and provide management advice for decision-making.
- Under the REBYC-III and EAF4SG Projects, the focus was on the gillnet fishery. It was expected that under these two projects, some length frequency data could be collected for the gillnet (another major gear capturing white salmon), that could be combined with the length frequency data from the trawl fishery to give a much better idea of stock status. The capture of small white salmon in the trawl was acknowledged and led to a management recommendation for BRDs (Bycatch Reduction Devices) to be introduced to address this. Under REBYC-II, to incentivize the use of the BRDs, the opportunity cost to the fishers - in terms of potential earnings that would be lost by the amount of small fish that would not mature to marketable size - was calculated at about $60,000 TT per trip. However, the relevant regulation to implement the management recommendation was not yet in place.
- Trinidad and Tobago’s collection of length data for marketable fish and discards was noted. The importance of including length data for discards - particularly when a length-based method such as fishblicc or LB-SPR was being applied with a species that had discards at sea - was emphasized, since the length frequency differed from the landed catch that was measured at the dock. Adding discards could lead to a very different SPR, depending on the selectivity assumed.

7.5 Preliminary Assessment for Shrimp from Artisanal & Non-Artisanal Trawl Fleets in Trinidad and Tobago, Gulf of Paria

The assessment was conducted in JABBA using combined landings data for five shrimp species (*Farfantepenaeus subtilis, F. notialis, Litopenaeus schmitti, Xiphopenaeus kroyeri, F. brasiliensis*) caught in the artisanal and non-artisanal (single stern, and double-rigged) trawl fleets in Trinidad and Tobago’s Gulf of Paria, for the period 1992 to 2014. Better data were available for the artisanal fleet and the small non-artisanal single stern fleet, hence the CPUE indices for those two fleets were used. The CPUE fits for the model showed a better fit for the non-artisanal single-stern fleet, compared to the artisanal fleet, which had some outliers. The assessment results showed biomass to be varying around the biomass at MSY and fishing mortality fluctuating around fishing mortality at MSY. The summary results tabulated by the model indicated MSY to be in the range of about 455,000 - 575,000 kg with a mean of 509,000 kg. The catch-over-the-time series did not vary too far from this, indicating a more or less sustainably exploited stock.

7.5.1 CSWG evaluation of Shrimp Assessment from Artisanal & Non-Artisanal Trawl Fleets, Trinidad and Tobago, Gulf of Paria

- CPUE indices were calculated for the artisanal fleet by dividing the total catch by the total effort for each year. Similarly, for the non-artisanal single-stern trawl fleet, the total catch was divided by the total effort to give a CPUE index for each year. These indices were derived from the raised data; however, in the future, it may be better to use the unraised catch and effort data (sample data).
- This assessment was a repeat of a prior assessment with two years of data added (2013-2014). In the previous assessment (1992-2012), an index was used for the same two fleets – artisanal and non-artisanal single stern; so, in order to add the data for 2013 and 2014, it was necessary to use the CPUE derived from the raised catch divided by the raised effort.
- The reason for the bimodal posterior probability density was possibly because these two CPUE indices were in conflict; perhaps the indices could be fitted separately and the impact observed on the results. This issue did not occur in the previous non-state space production model; further investigation was suggested, as the two peaks represented alternative views on the stock.

7.6 Preliminary assessment of the Surinamese gillnet and trawl data for *Cynoscion virescens*

An assessment of the Green weakfish (*Cynoscion virescens*) known locally as 'Kandratiki', was conducted in fishblicc using length frequency data from the gillnet and trawl fisheries collected from 2022 to 2025 by Fisheries Department data collectors and onboard observers, respectively. Length data were divided into bottom trawl and gillnet, and the lengths converted from 1 cm increments to 3 cm increments. The data were then plotted to obtain the observed and expected frequencies for the maximum posterior density fit with gillnet mixed selectivity, constant natural mortality, and logistic trawl selectivity. The results indicated a low SPR of 9.7%.

7.6.1 CSWG evaluation of the assessment of the Green weakfish (*Cynoscion virescens*)

- Regarding the SPR estimate, it was pointed out that this was more of a trial run, to look at and better understand selectivity. The key issue with multiple gears was their respective catches. The relative catch in numbers had to be supplied for each gear; however, in this case, the catch numbers were based on the sample size which may have been a relatively poor estimate. This was identified as an area to be further examined in order to get the fishing mortalities right and to consider alternative interpretations and sensitivities. With different assumptions and sensitivities, the SPR may well change. Additionally, grouping the data in different ways could also be considered to model selectivity better, bearing in mind partial mesh size changes in nets, and other similar details.

The reports of the five preliminary assessments attempted in the practical group sessions are given in ***Appendix 11***.

8.0 WORKSHOP CONCLUSIONS/RECOMMENDATIONS

General conclusions/recommendations

A. Given that the Guyana participants were unable to fully participate in the training activities due to internet and other technical challenges, it was agreed that arrangements would be made for Dr. Willems to conduct the training with the Guyana representatives, either electronically or in-person, at a later date. Participants expressed disappointment that their Guyana colleagues were unable to fully participate in this important training workshop. The CRFM Secretariat, with support from the EAF4SG Project, will make the necessary arrangements for the training to be conducted.

B. Training in the conduct of data-limited assessments using JABBA and fishblicc assessment packages, as well as the use of R Quarto to produce reports, will be incorporated, to the extent possible, in the curriculum of the CRFM Senior Data Assessment Group Training.

Fishery specific conclusions/recommendations

C. Acoupa weakfish (*Cynoscion acoupa*) fishery – The Fisheries Department should review the data in more detail; ensure that the input parameters are realistic to sensitivity analysis, and group the data in different ways. A length frequency dataset from 2017 to 2018 (data collected as part of a project) showed two peaks in the data, while the 2022-2025 data set used showed only one peak, so the reason(s) for this difference could also be investigated.

D. Barracuda (*Sphyraena guachancho*) fishery - Further study of the biology of the Barracuda, including size at maturity, to determine whether juveniles or mature fish were being caught, was required.

E. Green weakfish (*Cynoscion virescens*) fishery – Data on relative catches (how much the trawl caught relative to the gillnet) were also needed for the assessment (a default number was used for the preliminary assessment). Length data were being collected from both the gillnet and trawl fisheries; these data needed to be balanced with effort. This would have to be addressed before further work to refine the assessment could be done.

F. White Salmon (*Cynoscion leiarchus*) – Data and information from other gear (i.e., gillnet) capturing white salmon was needed to give a more realistic stock status.

9.0 WORKSHOP CLOSURE

The CRFM Secretariat Acting Executive Director, Dr. Sandra Grant, congratulated the participants on their hard work and focused attention throughout the training, and she highlighted their progress from theory to application over the 4-day period. Dr. Grant noted that the assessments attempted were only preliminary, as there were data and information gaps and other issues that would have to be addressed before complete assessments could be conducted and management advice provided to guide decision-making. She expressed hope for continued collaboration with EAF4SG and other regional projects to continue this assessment process.

Mrs. Nerisa Lucky, Technical and Project Coordinator, EAF4SG Project, said that the training had covered a lot of material. Participants would have learned a lot, and most importantly, the training would have built capacity of staff of the fisheries authorities. She thanked all the participants from Trinidad and Tobago, Suriname, and especially from Guyana for joining online. Mrs. Lucky took the opportunity to express thanks to the CRFM Secretariat and FISH4ACP for their administration of the workshop, and to the Government of Suriname and the staff of the Suriname Fisheries Department for hosting the workshop and coordinating in-country logistics. She also thanked the workshop facilitators for their hard work and said that she looks forward to continued collaboration to address the recommendations coming out of the workshop.

Dr. Marcelo Vasconcellos, Fishery Resources Officer, FAO, shared that the workshop was very productive. He remarked that the progress made over the four days from lectures to results was amazing and congratulated participants for their efforts. In terms of next steps, Dr. Vasconcellos said he would really like to see the preliminary assessments that were attempted in the workshop built up into rigorous and possibly validated stock assessments in the next year or so. He mentioned the possible resources required (more data, more technical support) to improve what was started in the workshop and signalled a willingness to support these efforts, in partnership with the CRFM Secretariat and the Fisheries authorities.

Information was shared regarding the arrangements for the planned field trip the following morning, to a demersal trawl catch and processing company. Information was also shared about a short boat trip planned for Friday afternoon to observe river dolphins, and participants were asked to indicate their interest so that the arrangements could be finalized.

There being no further interventions, Dr. Grant once again thanked everyone for their contributions towards making the training and capacity-building sessions a success and closed the workshop.

APPENDICES

APPENDIX 1: LIST OF PARTICIPANTS

Name	Address	Email Contact
	Fisheries Departments	
SURINAME		
Dr. Tomas Willems	Fisheries Department Ministry of Agriculture, Animal Husbandry and Fisheries Cornelis Jongbawstraat 50, Paramaribo **Suriname**	tomaswillems@gmail.com
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	CRFM SECRETARIAT	
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Mrs. June Masters Statistics & Information Analyst	CRFM Secretariat Botanic Gardens Rd., Montrose P. O. Box 2427, Kingstown **St. Vincent & the Grenadines**	june.masters@crfm.net
Ms. Pamela Gibson Administrative Secretary		pamela.gibson@crfm.int
	FISH4ACP Project	
Ms. Dawn Maison Technical Specialist	FISH4ACP Project – Guyana	dawn.maison@fao.org
	FAO	
Dr. Marcelo Vasconcellos Fishery Resources Officer	Food and Agriculture Organization Rome, Italy	Marcelo.Vasconcellos@fao.org
Mrs. Nerissa Lucky Technical and Project Co-ordinator	EAF4SG Project The University of the West Indies St. Augustine, Trinidad and Tobago	tpc_fisheries.proj@outlook.com
	CONSULTANTS	
Dr. Paul Medley	Seabob Working Group Consultant	paulahmedley@gmail.com

APPENDIX 2: AGENDA

CRFM Continental Shelf Fisheries Working Group (CSWG):
Data-limited Assessment of Groundfish Stocks for Suriname, Guyana and Trinidad & Tobago
31 March – 4 April 2025
Paramaribo, Suriname

PROVISIONAL AGENDA

Virtual Meetings

- Meeting with all workshop participants to review data needs for stock assessment and present data templates
- Separate meetings (one with each country) to review data before the workshop

In-person (31 March – 4 April 2025)

Morning session: 9:00 – 12:30 with coffee break at 10:30
Lunch break: 12:30 – 13:30
Afternoon session: 1:30 – 4:30 with coffee break at 15:00

Notes:
Times are for guidance only. Time will be allocated as needed during the workshop, in response to questions and observations from participants/stakeholders throughout the workshop.

Session	Activity	Personnel / lead
Day 1: March 31		
Morning	• Opening Ceremony • Welcome address and outline meeting agenda, activities and objectives • Introduction of participants • Introduction to stock assessment o Key concepts in stock assessment o Dynamics of exploited fish populations o How to obtain MSY o From MSY to management	Administrative, Technical Tomas Willems
Afternoon	• Harvest strategy development and evaluation • Data collection to support stock assessment • Introduction to data-limited models o Catch-based models (JABBA) o Length-based models (fishblicc) • "Toolkit" for stock assessment	Paul Medley Tomas Willems Paul Medley Tomas Willems/ Paul Medley
Day 2: April 1		
Morning	• Effort standardisation o simple GLM method with an example • JABBA assessment method for catch and standardised CPUE data	Paul Medley Pranaya Parida
Afternoon	• Length-based assessment: fishblicc • Introduction to Harvest Control Rules	Paul Medley Paul Medley
Day 3: April 2		
Morning	• Introduction to R Quarto • Data preparation and model selection (working groups per country)	Tomas Willems Paul Medley/ Tomas Willems

	• Reviewing input parameters for the assessed species	Paul Medley/ Tomas Willems
Afternoon	• Preliminary model runs (working groups per country)	Paul Medley/ Tomas Willems
Day 4: April 3		
Morning	• Preliminary model runs (working groups per country) – cont’d	Paul Medley/ Tomas Willems
Afternoon	• Sharing model results, exchange and lessons learned (presentations per country)	Paul Medley/ Tomas Willems
Day 5: April 4		
Morning	• Field trip: visit to fishery landing sites and discussion on length-data collection in the field	Tomas Willems
Afternoon	• Case study: validation of assessment of Atlantic seabob shrimp with stakeholders • Closing ceremony	Paul Medley/ Tomas Willems

APPENDIX 3: OPENING CEREMONY REMARKS

<u>Remarks – Mrs. Nerissa Lucky, Technical Project Co-ordinator, EAF4SG Project</u>

Good morning again, Assalam Wailaikum. I take this opportunity to extend Eid Mubarak greetings to our Muslim brothers and sisters celebrating EID ul Fitre today.

My name is Nerissa Lucky, and I am the Technical Project Coordinator of the EAF4SG Project.

EAF4SG is an Acronym. The Project's title is actually "Enhancing capacity for the adoption and implementation of EAF (An Ecosystem Approach to Fisheries) in the shrimp and groundfish fisheries of the North Brazil Shelf Large Marine Ecosystem (EAF4SG)". As the name EAF4SG implies, we encourage the adoption of holistic, inclusive fisheries management approaches that considers the entire ecosystem including biological, social, and environmental parameters to promote sustainable and resilient shrimp and groundfish fisheries in our target countries of Guyana, Suriname and Trinidad and Tobago.

It is no surprise then that the EAF4SG Project is partnering with the CRFM Continental Shelf Working Group and the FISH4ACP Project to co-sponsor this workshop. All the EAF4SG Project executing partners are CRFM Member States and we hope to build on this collaboration and expand our partnership to synergize with other regional partners such as the WECAFC Shrimp and Groundfish working group in future.

My job is very simple here this morning. I am tasked with chairing this morning's session and welcoming each and every one of you to this CRFM Continental Shelf Fisheries Working Group, Capacity Building Workshop on Data limited assessment of groundfish stocks for Suriname, Guyana and Trinidad and Tobago.

I welcome our participants from Trinidad and Tobago, and Suriname joining us in person, here at the beautiful Torarica Resort in Suriname. We also warmly welcome our colleagues from Guyana and others who are joining us virtually via live stream of this Workshop.

Special welcome to Dr Sandra Grant, Executive Director (Acting) of the CRFM and her very hardworking and efficient team, Ms. Dawn Maison, Technical Specialist of Fish4ACP Guyana, Dr Marcelo Vasconcellos, EAF4SG Lead Technical Officer based at the FAO in Rome and our very knowledgeable resource persons and consultants Dr Paul Medley and Dr Tomas Willems.

This stock assessment workshop is intended to be very practical and hands-on. We hope that your sessions will be interactive, and you will derive maximum benefit from the sessions planned.

In closing, I would like to thank the Director, Deputy Director, and Staff of the Fisheries Department of Suriname for coordinating numerous on the ground logistics and for hosting us in their very beautiful country.

We all recognize that it is a public holiday today in all three countries, and for our Trinidad and Tobago participants, it is also a Public Holiday tomorrow as well.

We sincerely thank all of you for your dedication and commitment to this learning process and for taking time away from your families and personal activities to participate in this workshop, learn from each other and share your knowledge and experience.

I wish you all a productive and interactive workshop and stakeholder meeting. Thank you.

Remarks – Dr. Sandra Grant, Deputy Executive Director, CRFM Secretariat

Mr. Zojindra Arjune, Deputy Director, Fisheries Department, Ministry of Agriculture, Animal Husbandry
Dr. Marcelo Vasconcellos, Fishery Resources Officer, FAO
Mrs. Nerissa Lucky, Technical & Project Coordinator, EAF4SG Project
Ms. Dawn Maison, Technical Specialist, FISH4ACP Project - Guyana
Dr. Paul Medley, Consultant
June Masters and Pamela Gibson, CRFM Secretariat Staff
Participants from Guyana (online), Suriname and Trinidad and Tobago (in-person)
Distinguished guests, ladies, and gentlemen

Welcome to the Caribbean Regional Fisheries Mechanism (CRFM) Continental Shelf Fisheries Working Group (CSWG): Workshop on Groundfish stock assessment and stakeholder consultation.

The CRFM CSWG seeks to foster the sustainable use of continental shelf resources and their associated ecosystems. This is achieved through the review and analysis of fisheries and related data, which are then used to develop appropriate management strategies. These strategies are designed to align with ecosystem-based, precautionary, and participatory approaches to fisheries management.

In 2024 the CRFM-CSWG, in collaboration with the FISH4ACP project, the Fisheries Departments of Suriname and Guyana, and the Seabob Working Groups of Guyana and Suriname, convened a joint assessment of the Atlantic Seabob fisheries of Guyana and Suriname, in Georgetown, Guyana, from March 11-15, 2024. That meeting focused on the assessment of the Atlantic Seabob Fishery. We also identified the importance of assessing the groundfish stocks. We are here today in collaboration with the EAF4SG project and the FISH4ACP project to make this a reality.

The groundfish resources in this region are crucial both economically and socially in this sub-region. Groundfish supports the livelihoods of local fishing communities and contribute significantly to the national economies of Guyana, Suriname, and Trinidad and Tobago. However, like many other countries, these countries face challenges in maintaining sustainable fisheries due to environmental changes and limited scientific data on the health of their fish stocks.

The development of a comprehensive groundfish stock assessment programme is critical to ensuring that these countries can manage their fisheries sustainably, maintain ecological balance, and ensure economic stability.

The workshop aims (i) to review and clean groundfish data for Guyana and Suriname, enhance stock assessment knowledge among data managers from Guyana, Suriname, and Trinidad and Tobago, and apply data-limited software tools in ‘R’ for stock assessments, focusing on at least one groundfish species per country. (ii) The workshop will also improve groundfish data collection methods for Trinidad and Tobago for stock assessment and involve consultations with Suriname's Seabob stakeholders to present the results and status of Suriname Seabob stock assessment.

We at the CRFM Secretariat believe that we need to build the capacity of fisheries managers to conduct stock assessment on national fisheries data. In 2023 we made a request to GRO-FTP under the auspice of UNESCO to convene a regional workshop in Barbados to conduct training in ‘R’ assessment. Since then, we have continued that training with the advance ‘R’ group and the introductory ‘R’ group. In 2025 we are continuing with the ‘R’ groups to provide support to Fisheries personnel to build their capacity and familiarity with the suite of ‘R’ Software. We want to support our fisheries personnel further, to develop the capacity of a new set of Data managers with the capacity to assess fisheries stocks.

We welcome our partners from FAO, UWI/EAF4SG, and FISH4ACP funded by GEF and the EU. This is not a problem to be solved by one organization, but us collectively. I hope we can continue to find the financial and technical resources to continue training officers in the region.

Welcome one and all to Suriname, it reminds me so much of Belize. A beautiful country, filled with a diverse group of people, speaking multiple languages and culture. Thanks to the government of Suriname for hosting us this week.

Have a wonderful meeting.

Remarks – Ms. Dawn Maison, Technical Specialist, FISH4ACP Project - Guyana

Good morning/afternoon everyone.

On behalf of FISH4ACP, I'm honoured to address this vital CSWG workshop. We commend the CRFM and the EAF4SG project for convening this crucial gathering, which underscores the importance of collaborative efforts in ensuring sustainable fisheries management.

FISH4ACP, an initiative of the Organisation of African, Caribbean and Pacific States (OACPS) implemented by FAO with funding from the European Union and the German Federal Ministry for Economic Cooperation and Development (BMZ), is dedicated to enhancing the productivity and sustainability of fisheries and aquaculture value chains. In Guyana, our work is deeply rooted in fostering inclusive and resilient growth, with specific focus on the Seabob value chain.

Our approach in Guyana extends beyond mere production increases. We are committed to driving improved livelihoods for fishing communities. This involves:

- Enhancing Value Chains: Optimizing the entire chain, from catch to market, ensuring fair returns for all stakeholders.
- Capacity Building: Empowering stakeholders with skills and knowledge for sustainable practices and improved business management.
- Promoting Diversification: Supporting alternative income streams, enhancing economic resilience.

A core focus is fostering behavioural changes that promote sustainability:

- Responsible Fishing Practices: Advocating for sustainable methods to minimize environmental impact.
- Reduced Post-Harvest Losses: Improving handling and processing to reduce waste.
- Promoting Stewardship: Encouraging ownership and responsibility for stock health.

Crucially, FISH4ACP recognizes the importance of collaboration. We believe sustainable management requires strong partnerships:

- Working with the Ministry of Agriculture: Aligning efforts with national priorities.
- Engaging with Fisherfolk Organizations: Understanding needs and ensuring relevant interventions.
- Collaborating with Research Institutions: Supporting data collection for informed decisions.
- Partnering with Regional Bodies: Promoting knowledge sharing and coordination.

We believe the project's most significant impact will be realized through sustained behavioural changes within the value chain and the fisheries department's enhanced capacity for evidence-based management.

A cornerstone of our approach is improved data management through the CALIPSEO web-based data management system and robust stock assessments conducted in collaboration with our partners, including the CRFM and Suriname. We view these not as one-off exercises, but as a shift toward a more informed and adaptive management regime. Consistent application of these tools will foster a culture of data-driven decision-making among stakeholders, enabling more accurate predictions of stock status and facilitating proactive adjustments to fishing practices.

Our assessments of Monitoring, Control, and Surveillance (MCS) activities, as well as the baseline study on the Chinese seine fishery, have provided critical insights into areas that require long-term attention. The recommendations from these studies necessitate behavioural changes in fishing practices to minimize environmental impacts and combat Illegal, Unreported, and Unregulated (IUU) fishing. The fisheries department's effective implementation of these recommendations, with support from initiatives like EAF4SG, is crucial for the long-term health and sustainability of the fishery and its ecosystem.

The formal recognition of informal fishing groups, a key element of our upgrade strategy, is another area where we anticipate long-term benefits. By empowering artisanal fishers, particularly women, with access to resources and representation, we're fostering a more inclusive and equitable governance structure.

Our domestic market analysis has identified pathways for increased profitability. However, realizing these opportunities sustainably requires behavioural shifts in market practices, value-added approaches, and effective supply chain management. The strengthening of the multi-stakeholder "Seabob Working Group" is instrumental in driving these changes.

It's important to emphasize that FISH4ACP's efforts are not operating in isolation. Our strong collaboration with the Caribbean Regional Fisheries Mechanism (CRFM) ensures that our findings and recommendations are aligned with regional best practices and contribute to broader sustainable fisheries management efforts. Additionally, synergies with projects like REBYC-III (Reducing Bycatch in Tropical Shrimp Trawl Fisheries) and EAF4SG are crucial for addressing the complex ecosystem impacts of the Seabob fishery and promoting more selective and environmentally friendly fishing techniques in the long term.

In conclusion, the deliverables of the FISH4ACP project in Guyana represent a significant investment in the long-term sustainability, profitability, and equity of the Seabob and groundfish value chains. The true measure of our success will be seen in the sustained behavioural changes adopted by fishers and other stakeholders, the enhanced capacity of the fisheries department to implement effective management measures, and the continued collaboration with regional partners, such as CRFM, and the FAO EAF4SG project. We believe this holistic approach promises a more resilient and prosperous future for Guyana’s fisheries, and we're committed to working with all of you to achieve that vision.

Thank you.

Introduction to fish stock assessment

TOMAS WILLEMS, PHD

Outline

1. Key concepts in stock assessment
2. Dynamics of exploited fish populations
3. How to obtain MSY
4. From MSY to management

Key concepts in stock assessments

Key concepts in stock assessments

Key concepts in stock assessments

CONCEPT 1 – THE STOCK

A stock assessment model is used to assess a fish population that has little or no mixing or interbreeding with other populations.

What is a fish stock?

"A unit stock is an arbitrary collection [of a single species] of fish that is large enough to be essentially self reproducing (abundance changes are not dominated by immigration and emigration) with members of the collection showing similar patterns of growth, migration and dispersal.

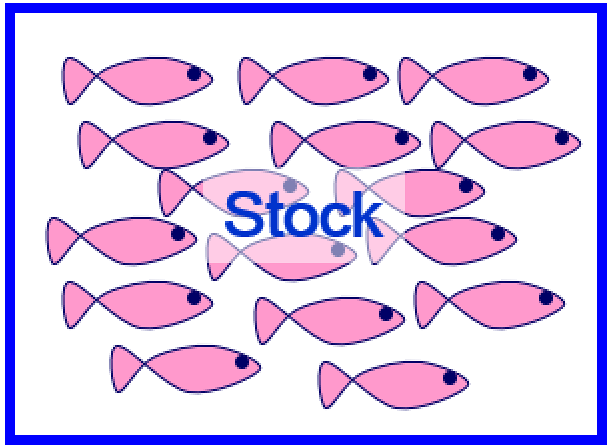
The unit should not be so large as to contain many genetically distinct races of subpopulations within it."

Hilborn and Walters (1991)

Key concepts in stock assessments

CONCEPT 1 – THE STOCK

1. Self contained
2. Management convenience
3. Scientifically meaningful
4. Little or no external influences



Key concepts in stock assessments

CONCEPT 1 – THE STOCK

How do we identify a fish stock?

It's a difficult task ………often little clear information. We can use:

Genetics

Tagging

CPUE analyses

Morphometrics

Often stock assessments are conducted on "stocks" where there is some uncertainty regarding the boundaries of the stock

Key concepts in stock assessments

CONCEPT 1 – THE STOCK

Yellowfin tuna – Pacific: limited mixing and genetic variation found

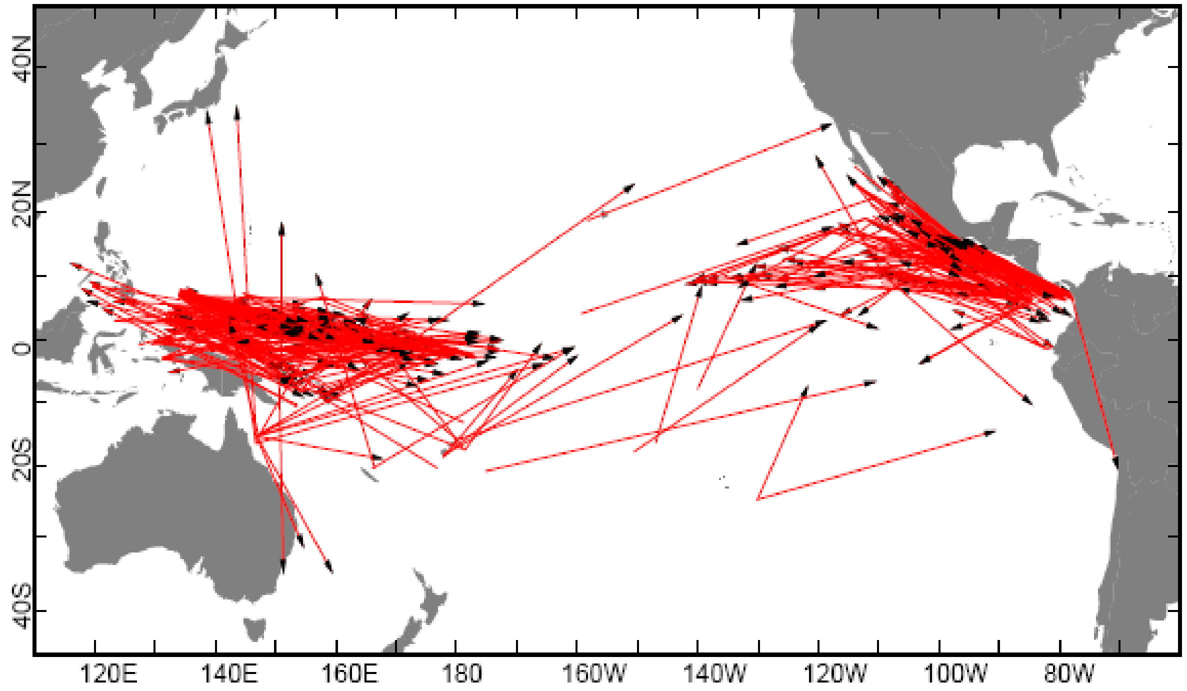


Figure 1. Long-distance (>1,000 nmi) movements of tagged yellowfin tuna.

Key concepts in stock assessments

CONCEPT 1 – THE STOCK

Skipjack tuna – Pacific: uncertainty regarding stock structure in the Pacific, but given a lack of evidence for trans basin movements and generally localised tag returns, mixing is thought to be limited within generations (short lived species) and in the medium term, meaning the “stock” is assessed as such for management purposes.

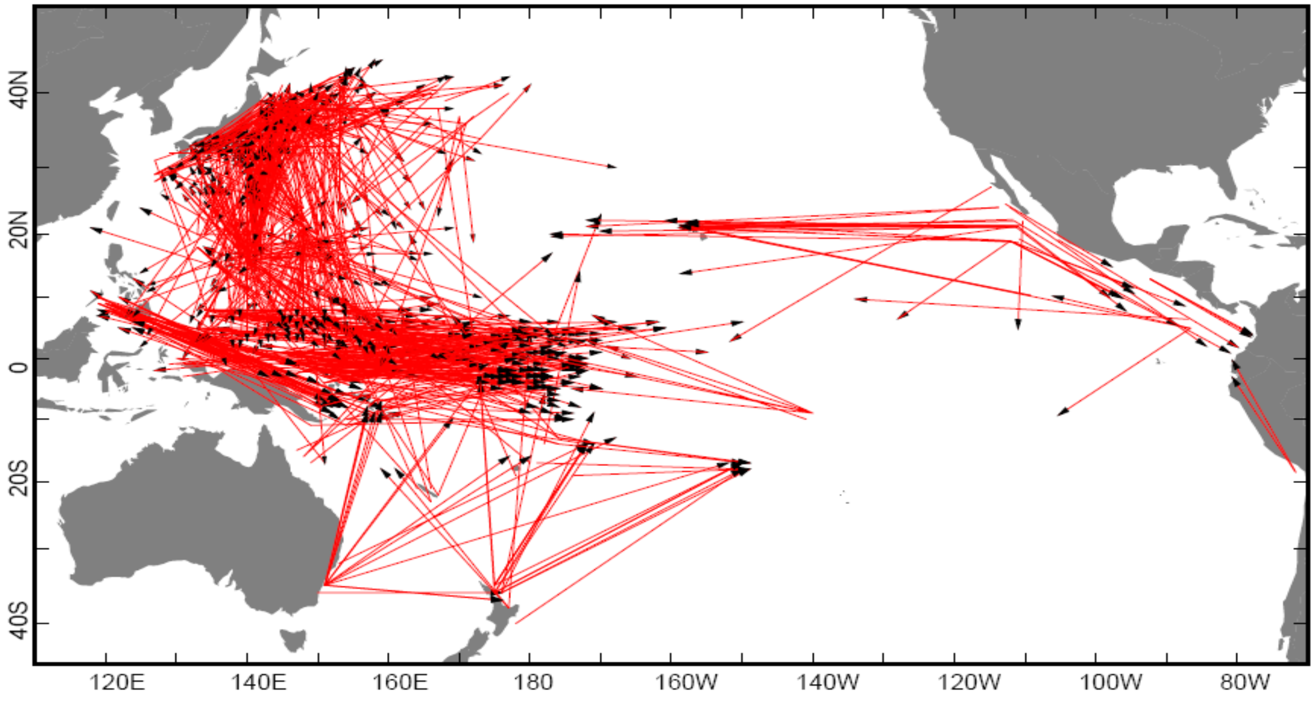


Figure 1. Long-distance (greater than 1,000 nmi) movements of tagged skipjack.

Key concepts in stock assessments

CONCEPT 2 – STOCK ASSESSMENT

Stock assessment is a **multi-step process** that starts with management questions, and includes processes involved in data collection, model selection, stock assessment modelling, and subsequent advice to decision makers.

Process	**Primary Responsibility**
1. Determine the questions to be answered	Managers & Policy makers
2. Choose an appropriate model	Scientists
3. Design and implement an appropriate data collection system	Scientists, managers, fishers
4. Collect the required data:	Fishers, scientists, managers
5. Build the model	Scientists
6. Run the assessment	Scientists
7. Interpret the assessment Results	Scientists, managers, policy makers
8. Scientific advice to decision makers	Scientists
9. Decision makers make decisions	Managers & Policy makers

Key concepts in stock assessments

CONCEPT 3 – STOCK ASSESSMENT MODEL

A stock assessment model provides a simplification of a very complex system (fish and fishery), to help us estimate population changes over time in response to fishing

Key concepts in stock assessments

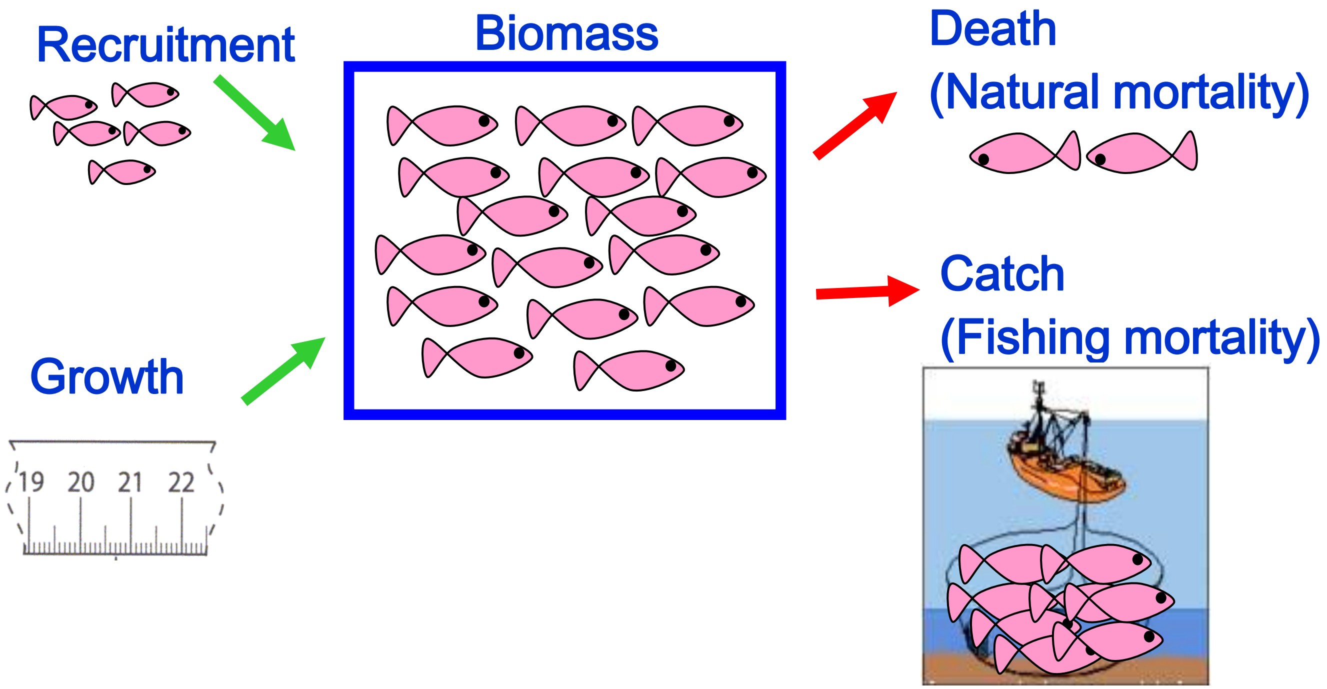
CONCEPT 3 – STOCK ASSESSMENT MODEL

Stock assessment is done by building a **model** that provides a simplification of a very complex system (fish and fishery), to help us estimate population changes over time in response to fishing

A **model** is a mathematical representation (or description) of a system that is used to help us understand the system and how the system works

Key concepts in stock assessments

CONCEPT 3 – STOCK ASSESSMENT MODEL

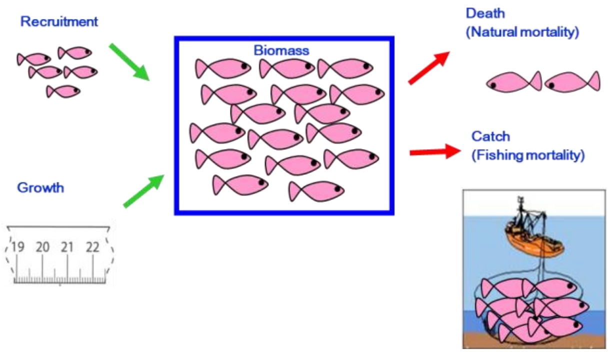


Key concepts in stock assessments

CONCEPT 3 – STOCK ASSESSMENT MODEL

Stock size fluctuations can be estimated by accounting for four key processes: additive processes (**growth, recruitment**) and subtractive processes (**fishing mortality, natural mortality**) over time.

$$B_{t+1}=B_t+R+G-M-C$$



This is a simple mathematical model of our fish population. It describes a **system** (fish population) and the **processes** that effect that system (recruitment, growth, mortality). It provides us a simplification of a complex system to help us understand that system, predict how it will react to different conditions, so we can make informed decisions regarding its management.

Key concepts in stock assessments

CONCEPT 4 – PROCESSES AND EQUATIONS

A stock assessment model describes processes within the model as **mathematical equations**.

To understand how stock assessments work at a technical level, it is important to understand the key types of equation used and how they are used….

Key concepts in stock assessments

CONCEPT 4 – PROCESSES AND EQUATIONS

An equation can be thought of as simply being a sentence, but the words have been replaced by symbols….for example:

$$B_{t+1=}B_t+R+G-M-C$$

If we know what the symbols mean, we can read the sentence!

"Population biomass next year is equal to the biomass this year, plus biomass of new recruits in one years time, plus biomass of additional growth of this years fish, minus biomass of fish that died of natural causes, minus the biomass of fish killed by fishing".

Large stock assessment models can involve complex equations expressing mathematical and statistical functions which attempt to describe the interacting fishery and fish population processes. Interpreting those interlinking equations requires training in maths, statistics and computer programming.

However, we don't need to have all that training to get a basic understanding of how stock assessment models work.

Key concepts in stock assessments

CONCEPT 5 – FITTING MODELS TO DATA

Key processes in stock assessment modelling include:

1. Developing a realistic mathematical description (model) of population processes and their interaction with the fishery and,
2. **“Fitting” that model to real (observed) data** which indexes changes in population size, structure and movement, to ensure the model can provide…
3. Realistic estimates of uncertain or unknown parameters within the model, so enabling….
4. Use of the model in predicting current and future fishing impacts upon the fish population and fishery

“Fitting” is typically achieved via either minimization of the sums of squares of errors or maximum likelihood approaches.

Key concepts in stock assessments

CONCEPT 5 – FITTING MODELS TO DATA

Once we have a basic model which describes the key interacting processes, we are left with the task of **collecting the data to inform each parameter in the model**, so we can use the model to understand the current/future fishery.

The problem is this: Some parameters we can collect data for (catch, fishing effort, sizes, growth rates, maturity etc) but some parameters we may not be able to collect data for or estimate outside the model.

This creates significant **uncertainty** in our models ability to predict changes in population size and structure due to fishing and other processes.

Key concepts in stock assessments

CONCEPT 5 – FITTING MODELS TO DATA

How do we get around this?

Fortunately, it is possible to use the model itself to estimate the value of the unknown parameters, through the process of **“fitting” the model to observed data from the fishery.**

Key concepts in stock assessments

CONCEPT 5 – FITTING MODELS TO DATA

How does model fitting work? An example….

1. Collect data which will index changes in the fish populations size over time. Typically this is catch rate or **catch-per-unit-effort (CPUE)** data. We assume that CPUE is directly proportional to population size, (if CPUE goes up, the population has gotten bigger; if it goes down, it has gotten smaller) and is therefore an accurate index of population change over time.

2. Use a statistical model (and computer) to search for and find the combination of "uncertain or unknown" parameter values which allow the model to most closely **predict the observed CPUE data trend**. (Essentially the computer tests across 1000s or 10000s of different possible parameter values until it finds the combination that gives the best "fit" between observed and predicted CPUE)

Key concepts in stock assessments

CONCEPT 5 – FITTING MODELS TO DATA

Why do we use this approach?

Because we **believe the CPUE trend is proportional to and accurately reflects population (biomass) trends**. So if our model can predict our CPUE trend, and CPUE relates directly to biomass, then it can predict our biomass trend.

Models can also be fit to size data (to ensure the model is realistically predicting population size/age structure) and to tagging data (to ensure the model is realistically predicting fish movements).

Key concepts in stock assessments

CONCEPT 5 – FITTING MODELS TO DATA

Summary of model fitting

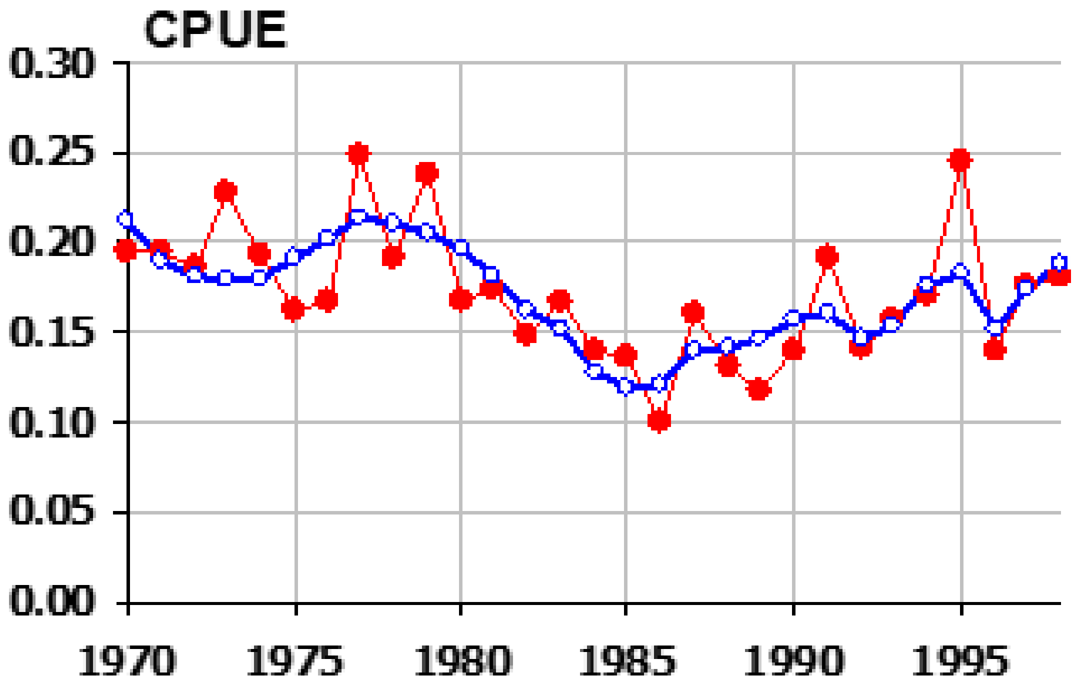
1. We use our knowledge of population processes **to build a model** of the population that has equations to describe all the processes, how they link together, and how they influence population size over time.

2. Each **equation** will be made up of different components (or parameters)

3. Some of the **parameter values** we will know already (e.g., from biological research, from fisheries catch effort data collection, etc). Some of the parameters will have unknown values.

4. We use a statistical model (and computer) to go through all the different combinations of possible values for those unknown parameters, until **it finds a combination that allows the model to accurately predict the observed CPUE**. In other words, produce a CPUE time series that fits or matches (i.e. differs very little from..) the real CPUE time series.

Key concepts in stock assessments



Key concepts in stock assessments

REVIEW OF CONCEPTS SO FAR

Concept 1 – A **stock** is a fish population that has little or no mixing or interbreeding with other populations.

Concept 2 – **Stock assessment** is a multistep process that starts with management questions regarding the impact of fishing on the stock, and includes processes involved in data collection, model selection, stock assessment modelling, and subsequent advice to decision makers.

Concept 3 - A **stock assessment model** provides a simplification of a very complex system (fish and fishery), to help us estimate population changes over time in response to fishing, and predict population changes in future in response to management actions

Concept 4 - The estimation of biomass and the above processes within the model relies on various types of **equations**

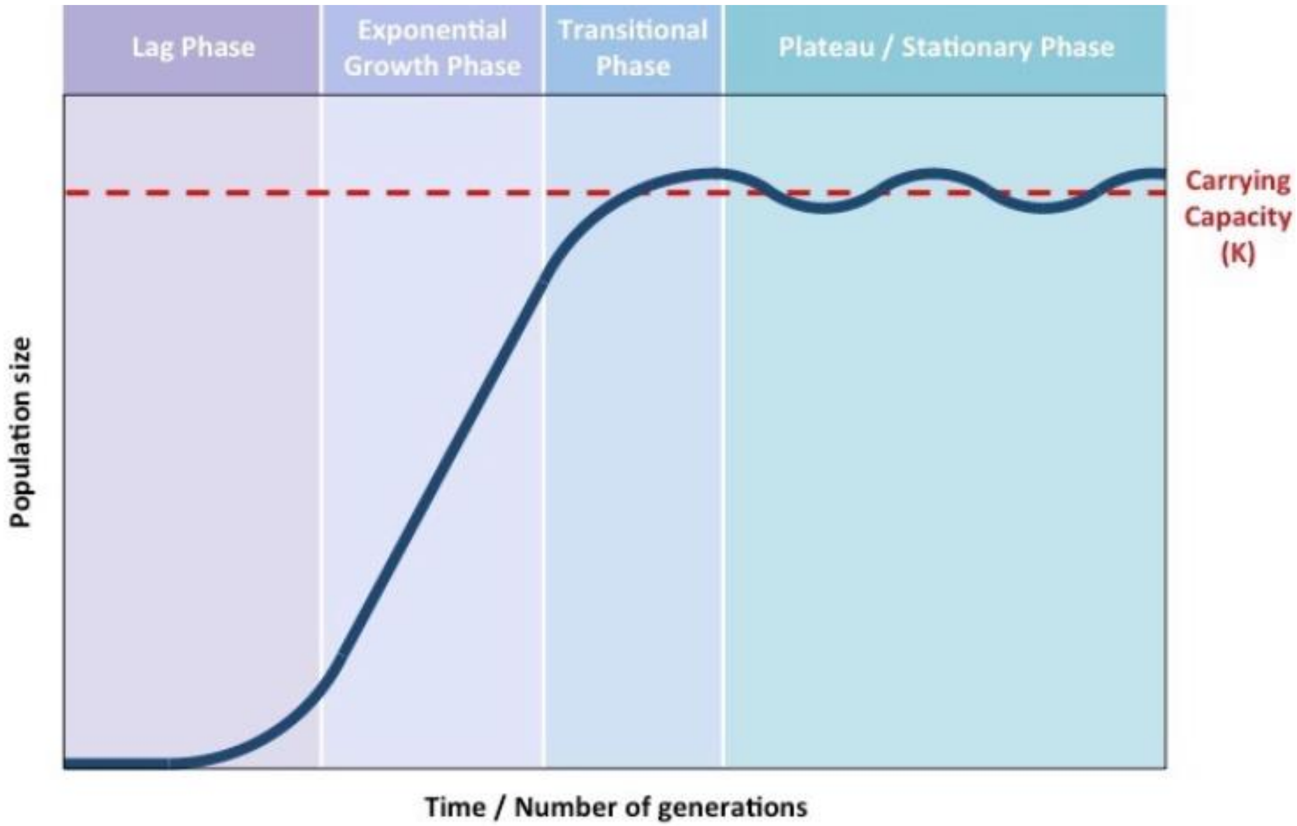
Concept 5 - We use our knowledge of population processes to **fit a model** of the population that has equations to describe all the processes, how they link together, and how they influence population size over time.

Dynamics of exploited fish populations

Dynamics of exploited fish populations

Dynamics of exploited fish populations

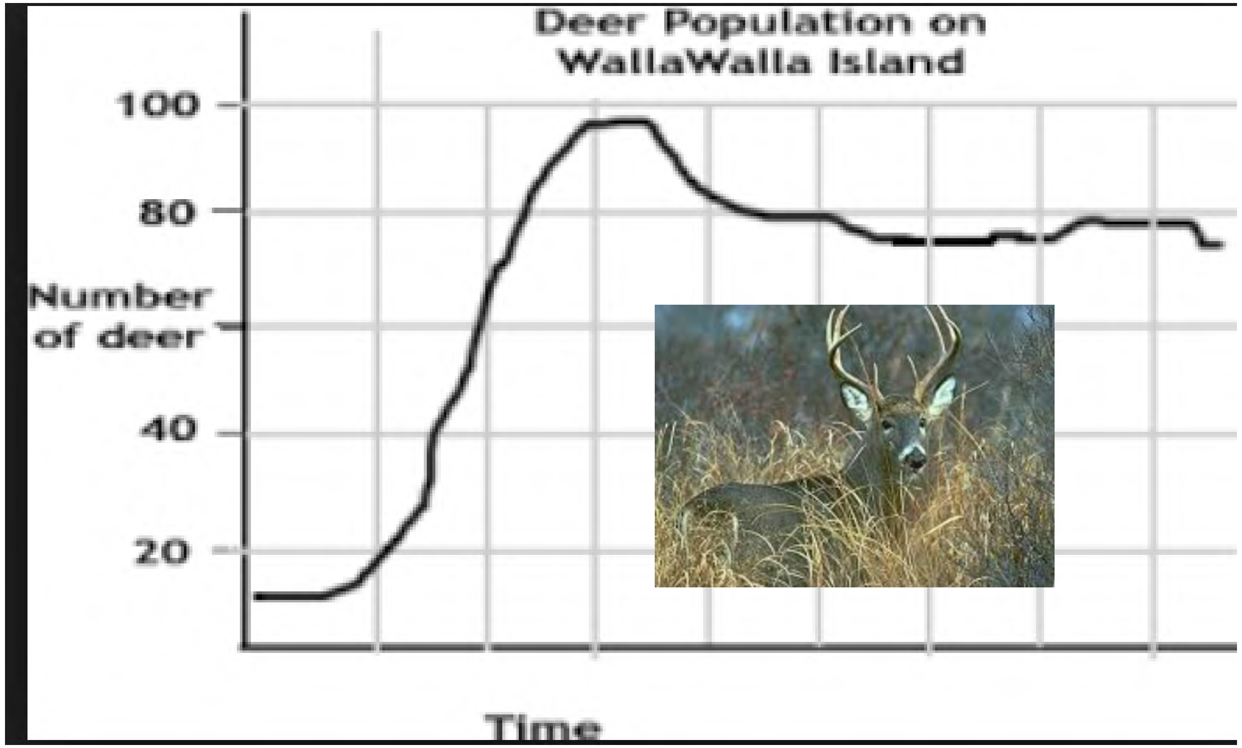
POPULATION GROWTH CURVE



Carrying capacity of a population is the maximum density of a population that the environment can support over a sustained period without damage to the environment

Dynamics of exploited fish populations

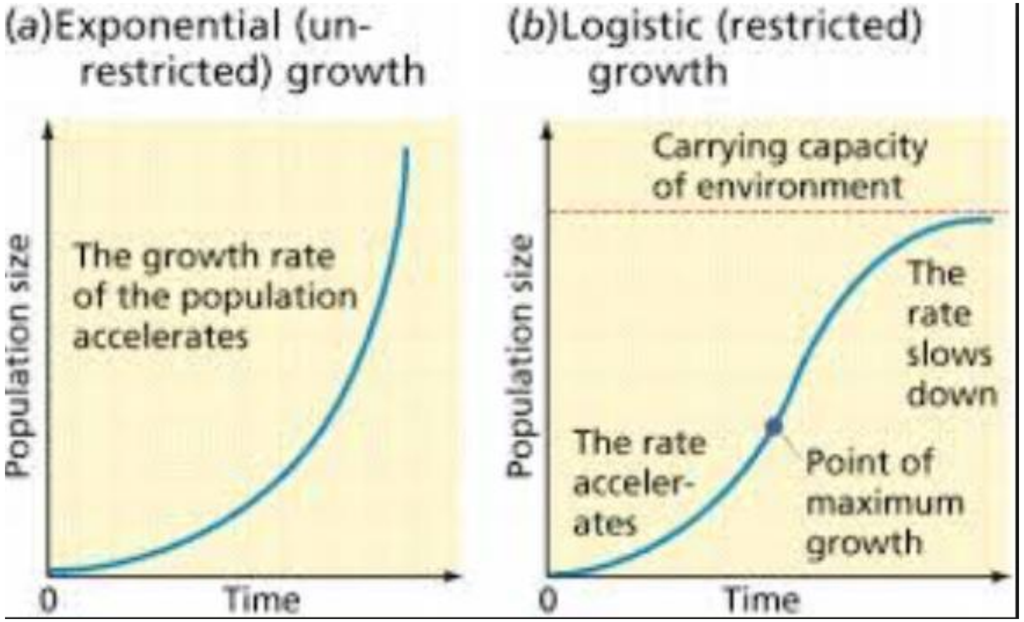
POPULATION GROWTH CURVE



Carrying capacity of a population is the maximum density of a population that the environment can support over a sustained period without damage to the environment

Dynamics of exploited fish populations

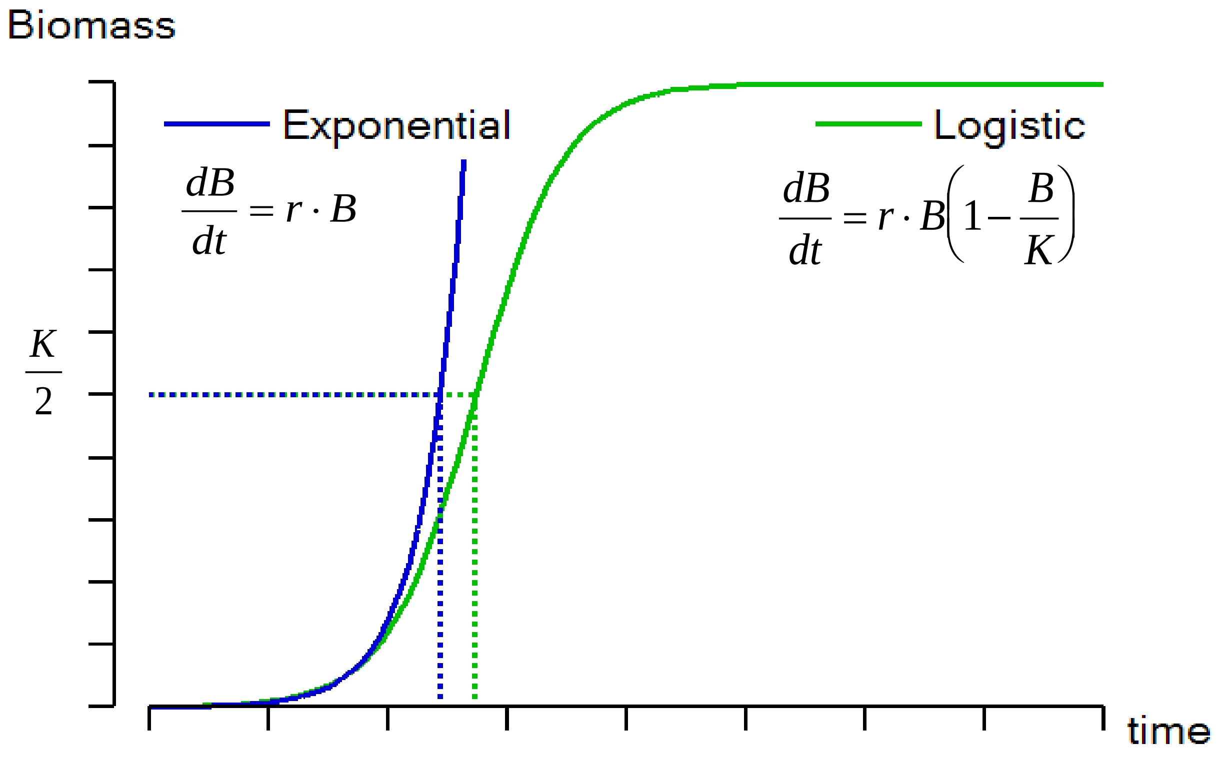
POPULATION GROWTH CURVE



Carrying capacity of a population is the maximum density of a population that the environment can support over a sustained period without damage to the environment

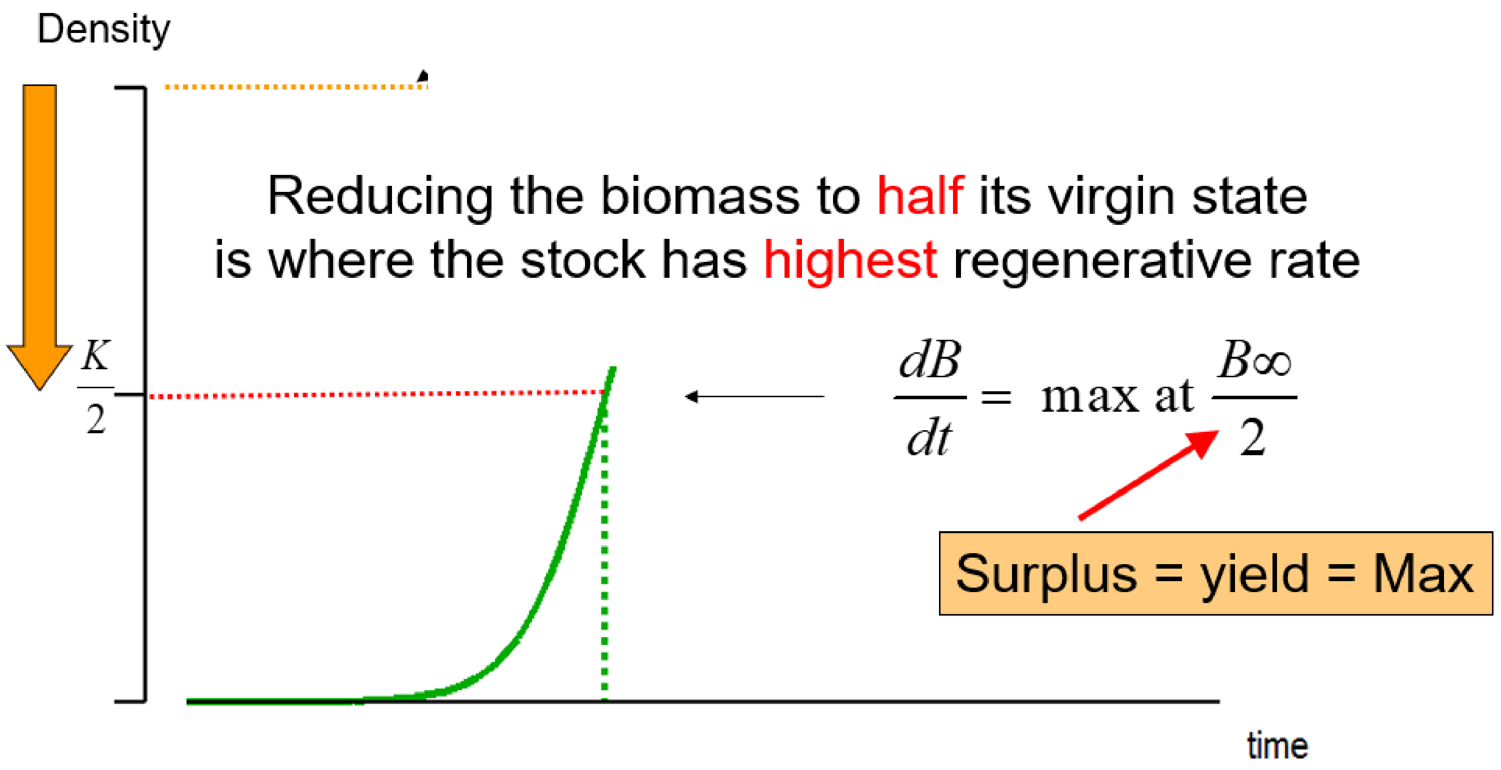
Dynamics of exploited fish populations

POPULATION GROWTH CURVE



Dynamics of exploited fish populations

DENSITY DEPENDENCE

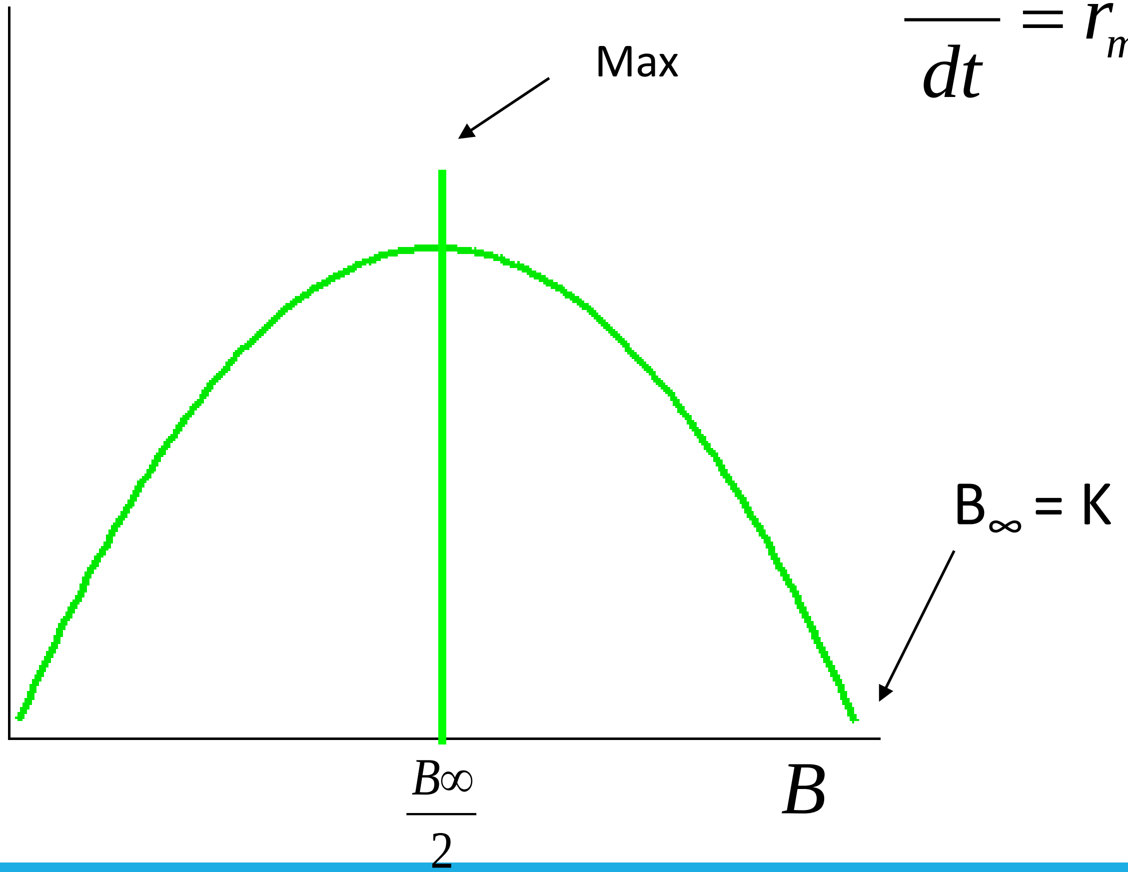


Dynamics of exploited fish populations

SURPLUS PRODUCTION

$$\frac{dB}{dt} = r_m \cdot B\left(1 - \frac{B}{K}\right)$$

$$\frac{dB}{dt} = \text{Surplus production}$$



Dynamics of exploited fish populations

MSY & MANAGEMENT

One Problem in Fisheries Management

"What you catch today won't be able to spawn and produce offspring tomorrow"

versus

"You can't sell (and people can't eat) fish you don't catch; what you don't catch today may or may not produce offspring tomorrow."

Management choices should be viewed as a gamble:
If harvest is too big ==> less fish and money in future;
If harvest is too small ==> less fish and money now.

Dynamics of exploited fish populations

MSY & MANAGEMENT

Objectives of a Stock Assessment

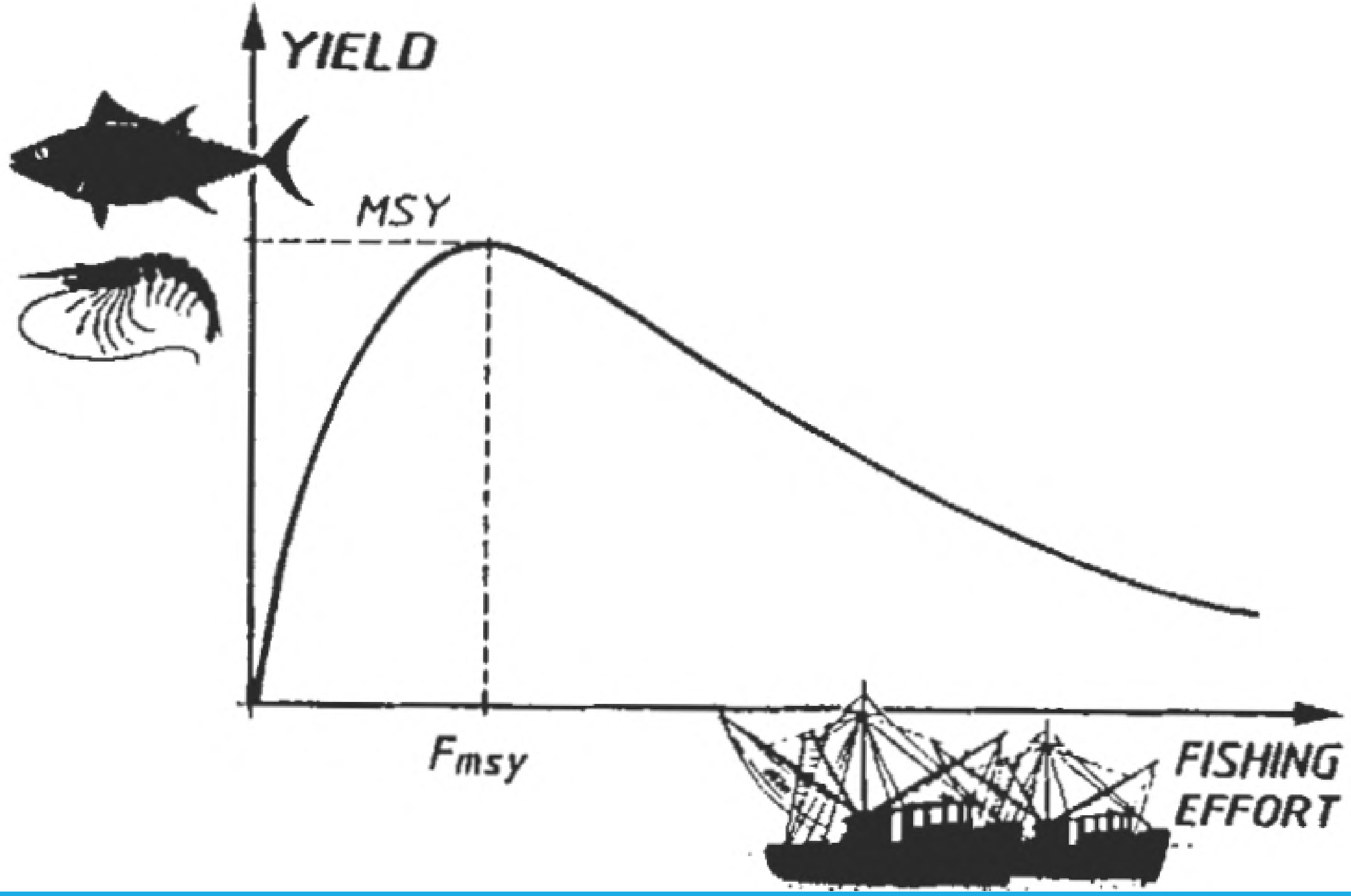
<u>Estimate the current status of the stock.</u> How many exploitable fish? How many new recruits?

<u>Determine an appropriate target rate for fishing.</u> What fraction of the stock can be harvested safely? Balance short-run catches against possible changes in the long-run biological productivity.

Analogous to a bank statement: stock size is the account balance; harvest rate is the interest rate.

Dynamics of exploited fish populations

MSY & MANAGEMENT



How to obtain MSY?

How to obtain MSY?

FUNDAMENTAL FISHERIES EQUATION

In its most simplistic term we can think of the catch being a function of biomass:

Catch = Fishing pressure x Biomass, more succinctly

$$C = F\ B$$

Think here of the fishing pressure as the proportion of the biomass that is removed by fishing:

$$F = C / B$$

often termed **harvest rate** or **fishing pressure**.

We can think of C = FB as **MSY =** $F_{MSY}\ B_{MSY}$

How to solve this equation??

How to obtain MSY?

TWO C = FB SCENARIOS

Imagine we have a total catch (data) of some 200 t over a month. This catch could have arisen from different scenarios, e.g.:

Scenario 1: Fishing pressure = 0.2, Biomass = 1000 t

C = FB

Catch = 0.2 x 1000 t = 200 t

Scenario 2: Fishing pressure = 0.4, Biomass = 500 t

C = FB

Catch = 0.4 x 500 t = 200 t

So a certain catch can come from a high stock size using a low fishing pressure or from a low stock size using high fishing pressure.

Catch alone does not inform us about biomass nor fishing pressure.

How to obtain MSY?

ON FISHING PRESSURE

The fishing pressure can be split into two components:

F = qE, where:

Effort (E): The question of **how much**?

Catchability (q): The question of **how**? We can think of this term as fishing efficiency.

How to obtain MSY?

TWO F = qE SCENARIOS

Scenario 1: 10 small vessels go out for 1 day

Total effort: 10 fishing days

Catchability: 0.01

F = q E: 0.01 x 10 = 0.1

Scenario 2: 1 large vessels go out fishing for 1 day.

Total effort: 1 fishing days.

Catchability: 0.10

F = qE = 0.10 x 1 = 0.1

We can exert the same fishing pressure (and hence obtain the same catch) by having high effort and low catchability or low effort and high catchability. **So, effort alone does not inform us on fishing pressure.**

How to obtain MSY?

FUNDAMENTAL FISHERIES EQUATION

$$MSY = F_{MSY}\ B_{MSY}$$

How to solve this equation??

WE NEED A MODEL

How to obtain MSY?

WHAT CONTROLS BIOMASS

The biomass of the fish at any one time is a product of:

- Existing biomass (B)
- Added biomass in form of growth of existing fish (G)
- Added biomass in form of new recruitment coming in (R)
- Loss of biomass in form of natural mortality (M) (Predation, starvation, disease)
- Loss of biomass in form of catch (C)

So over time we have gains in form of growth and recruitment and loss because of natural causes and fishing.

How to obtain MSY?

BIOMASS OVER TIME

Over time (here over one time step, from time t to t+1) we can expressed this in terms of a mass-balance equation:

$$B_{t+1} = B_t + G_t + R_t - M_t - C_t$$

Expressing fish population dynamics in this form raises questions:

Which of these variables do we currently have measures of?

Which of these variables can we possibly obtain measures of?

Which of these variables can we likely never obtain any measurements of?

Which of these variables can we manage?

How to obtain MSY?

BIOMASS OVER TIME

We can apply this simplification:

$B_{t+1} = B_t + G_t + R_t - M_t - C_t$

$B_{t+1} = B_t + P_t - C_t$

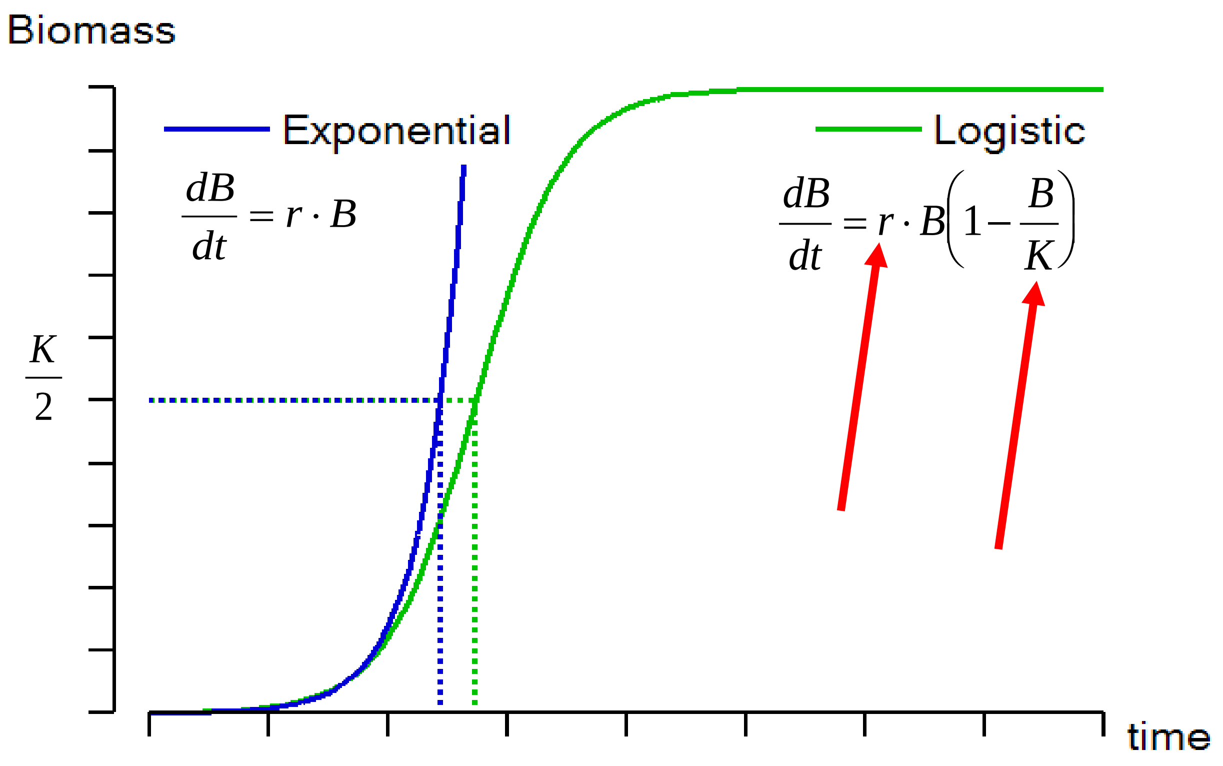
P_t is often referred to as **production**

A traditional stock assessment method is model biomass over time in a so-called **surplus production model,** using time series of:

- **Catch (C)**
- **Catch-per-unit-effort (CPUE, as an index for production, P)**

How to obtain MSY?

BIOMASS OVER TIME



How to obtain MSY?

SURPLUS PRODUCTION

$$\frac{dB}{dt} = r_m \cdot B\left(1 - \frac{B}{K}\right)$$

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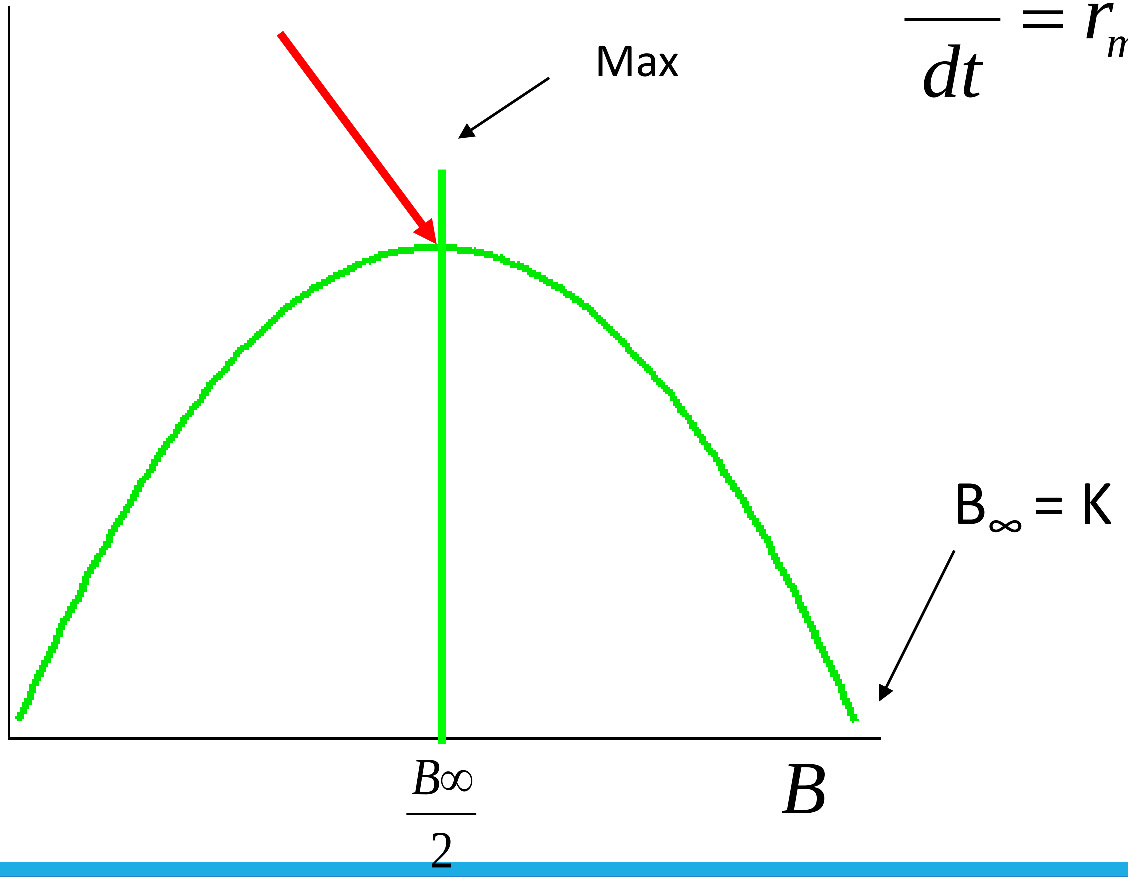


How to obtain MSY?

SOLVING THE EQUATION

Biomass giving maximum sustainable yield

$$B_{MSY} = K/2$$

Fishing mortality rate leading to B_{MSY}

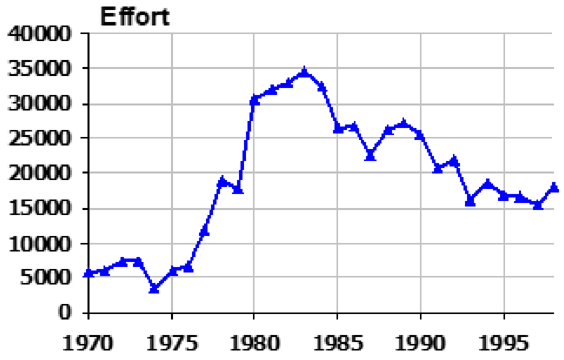
$$F_{MSY} = r/2$$

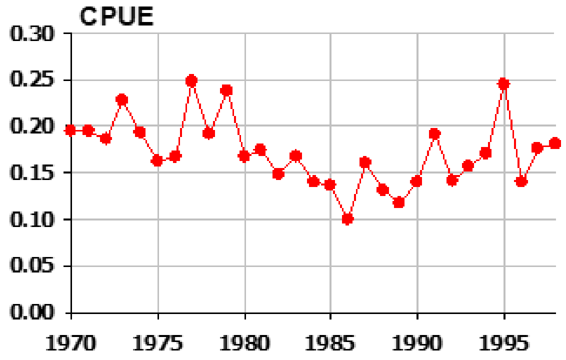
Maximum sustainable yield

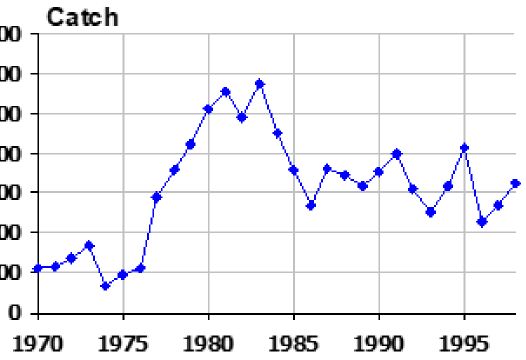
$MSY = F_{MSY} * B_{MSY} = r/2 * K/2 = rK/4$

How to obtain MSY?

Norther-Australia Tiger Prawn Fishery







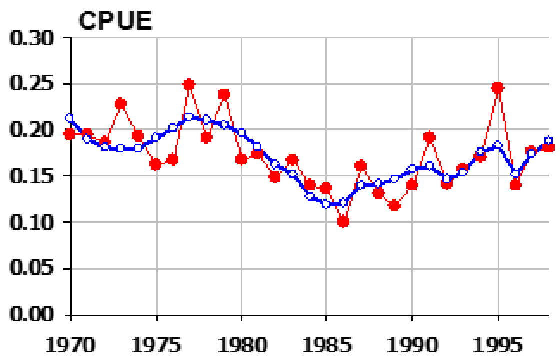
History of fishery:
1970-76: Effort and catch low, cpue high
1976-83: Effort increased 5-7fold and catch 5fold, cpue declined by 3/4
1985-: Effort declining, catch intermediate, cpue gradually increasing.

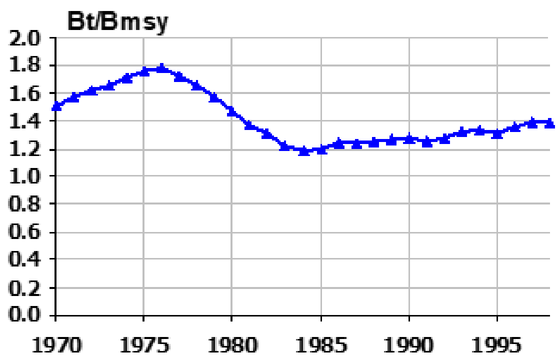
Objective: Fit a stock production model to the data to determine state of stock and fisheries in relation to reference values.

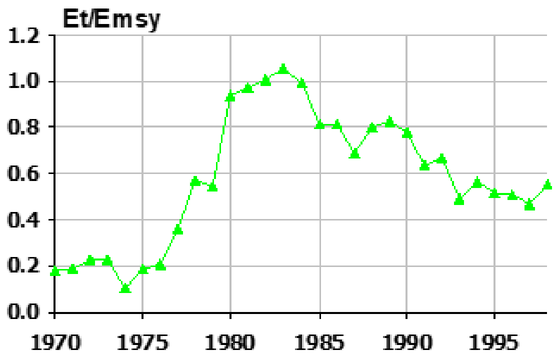
Haddon 2001

How to obtain MSY?

Norther-Australia Tiger Prawn Fishery







The observe catch rates (red) and model fit (blue).
Parameters: r= 0.32, K=49275, Bo=37050
Reference points:
MSY: 3900
Emsy: 32700
Bcurrent/Bmsy: 1.4

The analysis indicates that the current status of the stock is above Bmsy and that effort is below Emsy.
Question is how informative are the data and how sensitive is the fit.

Haddon 2001

From MSY to management

From MSY to management

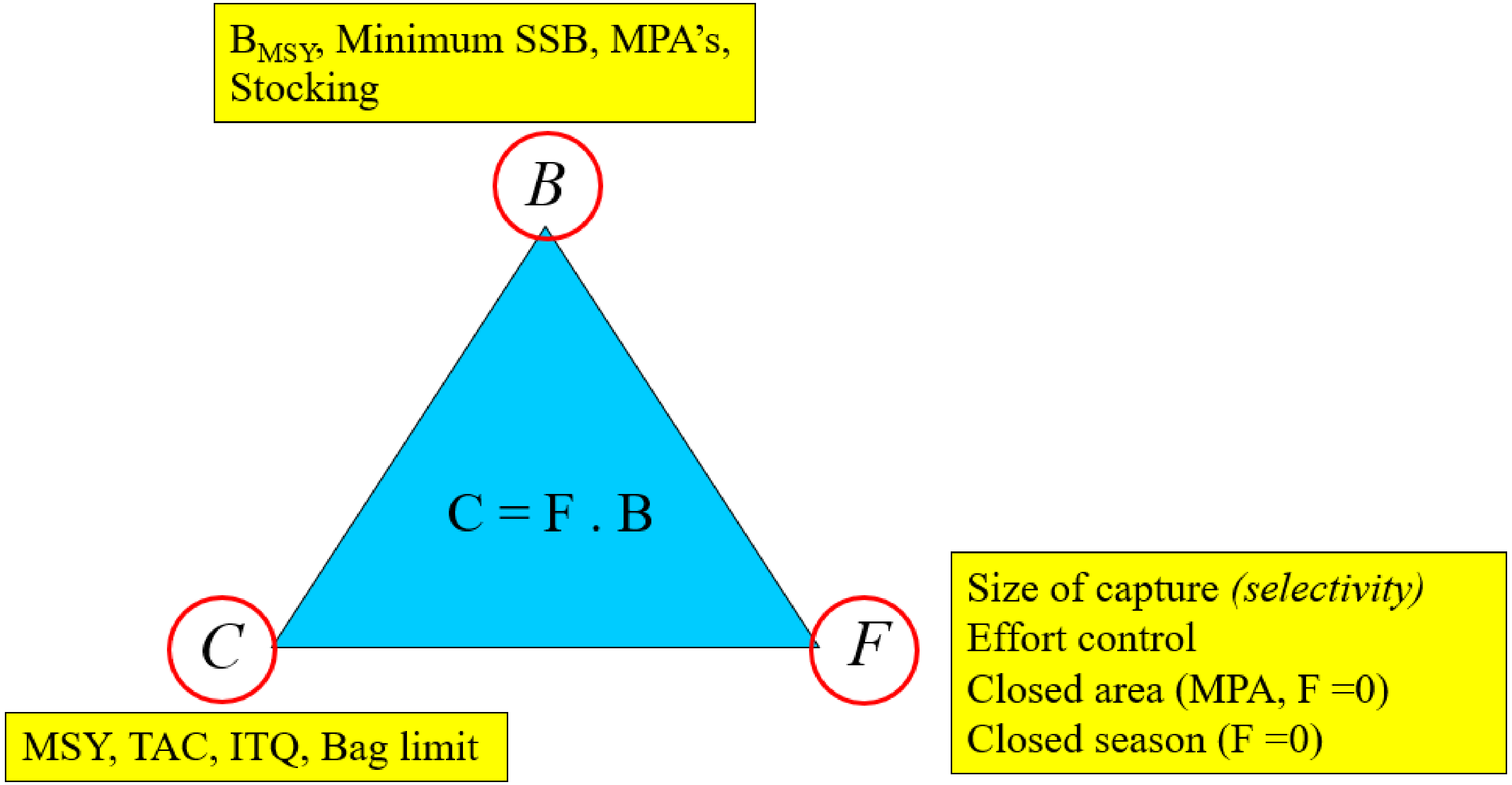
OPTIONS FOR MANAGEMENT

Remember C = FB or **MSY =** F_{MSY} B_{MSY}

We can manage fishery based, on **catch**, **fishing pressure** or **biomass**

From MSY to management

OPTIONS FOR MANAGEMENT



From MSY to management

EXAMPLE: GUYANA/SURINAME SEABOB FISHERY

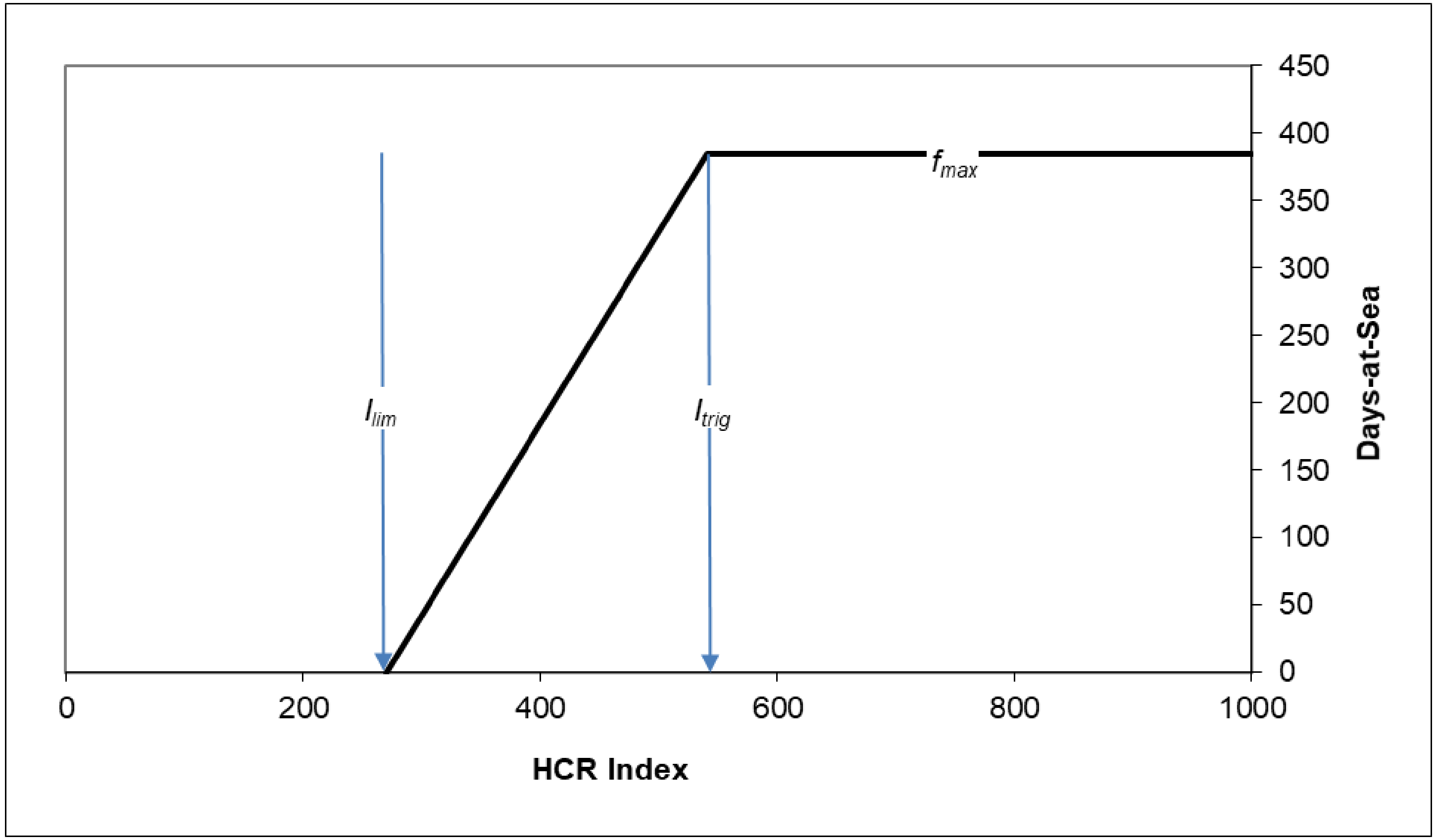
2019: updated stock assessment for Guyana and Suriname seabob fishery (surplus production model)

Effort management using a **Harvest Control Rule**

HCR Parameter	Value
f_{max}	f_{MSY}
f_{min}	0
ma	0.75
R	15%
I_{trig}	0.8 I_{MSY}
I_{lim}	0.5 I_{MSY}

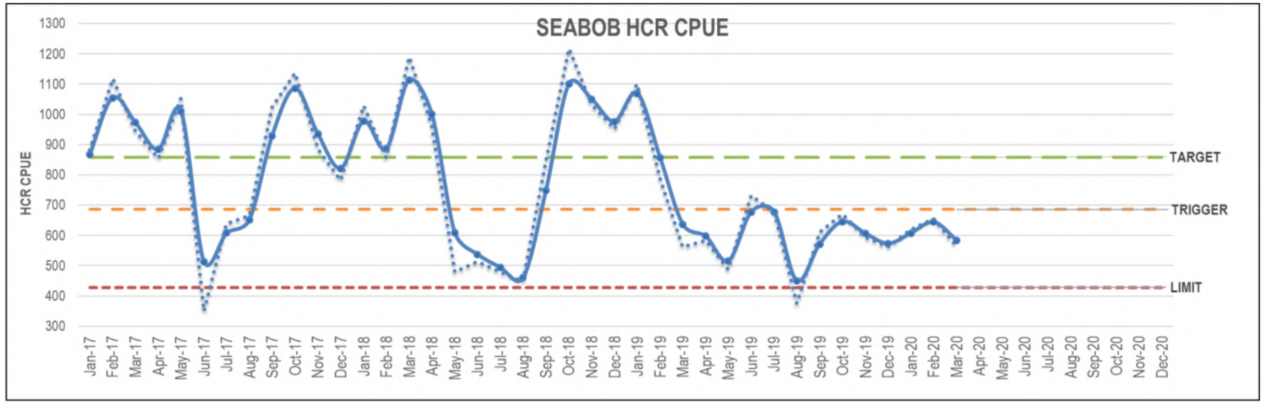
From MSY to management

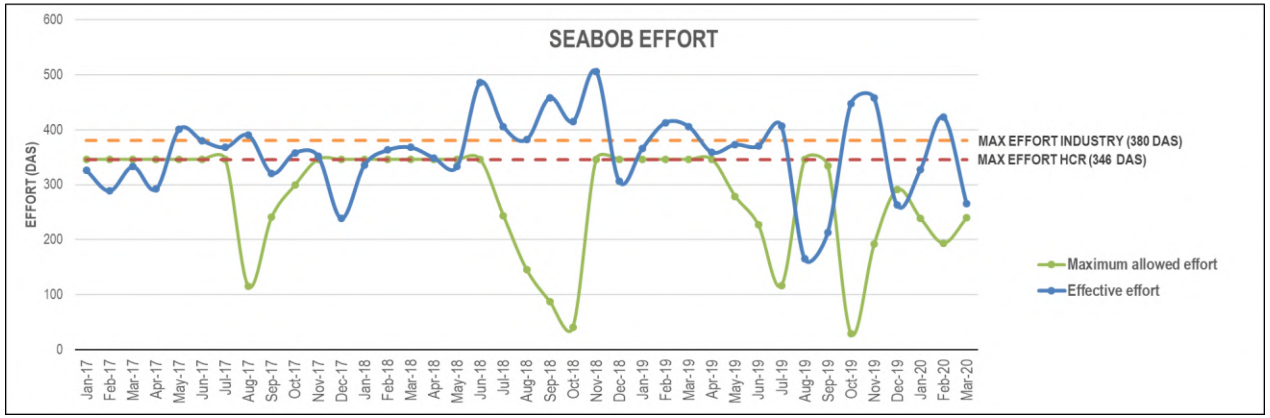
EXAMPLE: GUYANA/SURINAME SEABOB FISHERY



From MSY to management

EXAMPLE: GUYANA/SURINAME SEABOB FISHERY





From MSY to management

EXAMPLE: GUYANA/SURINAME SEABOB FISHERY

C	D	E	F	G	H	I	J
						HCR	
						CPUE	Control Max Effort
		MA Parameter	0.75		Limit	428.86	0
					Trigger	686.17	346
		Recovery	1.15		Target	857.71	346
Year	Month	Catch (kg)	Effort	Observed CPUE	HCR CPUE	Quarterly	Effort Quota for next month
2019	5	182242	373	488.59	515.80	679	279
2019	6	270771	370	731.81	677.81	306	227
2019	7	275733	407	677.48	677.56	1038	117
2019	8	62235	166	374.91	450.57	631	335
2019	9	130313	213	611.80	571.49	465	334
2019	10	299584	447	670.21	645.53	1038	29
2019	11	271979	458	593.84	606.76	591	192
2019	12	147780	263	561.90	573.12	133	291
2020	1	202463	327	619.15	607.64	1038	239
2020	2	277663	423	656.41	644.22	711	194
2020	3	150218	266	564.73	584.60	288	240
2020	4	0	-1	-1.00	672.29	1038	290
2020	5	0	-1	-1.00	773.14	1038	209
2020	6	0	-1	-1.00	889.11	1038	327

JABBA: State Space Production Models

Paul A Medley (paulahmedley@gmail.com)

2022-10-28

GENERAL DEPLETION MODELS

Basic Population Model

$$P_{t+1} = P_t + B_t - D_t + I_t - E_t$$

- Closed Population
  - No immigration or emigration

$$I_t = E_t = 0$$

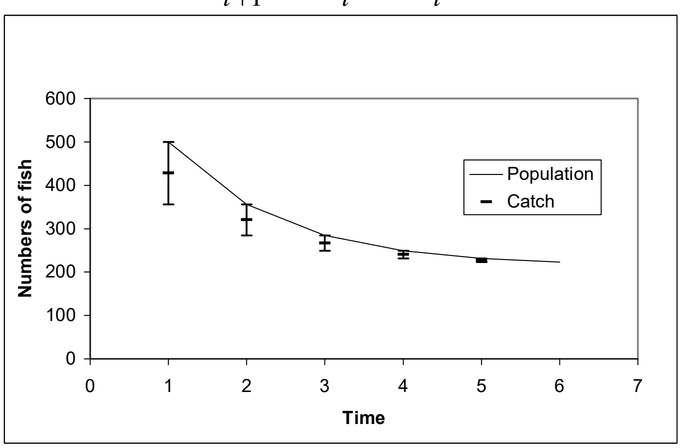
- Stock Definition
  - Stock assumes the population is closed with respect to recruitment.

$$B_t = f(P_t)$$

$$P_{t+1} = P_t + f(P_{t-d}) - M_t - F_t$$

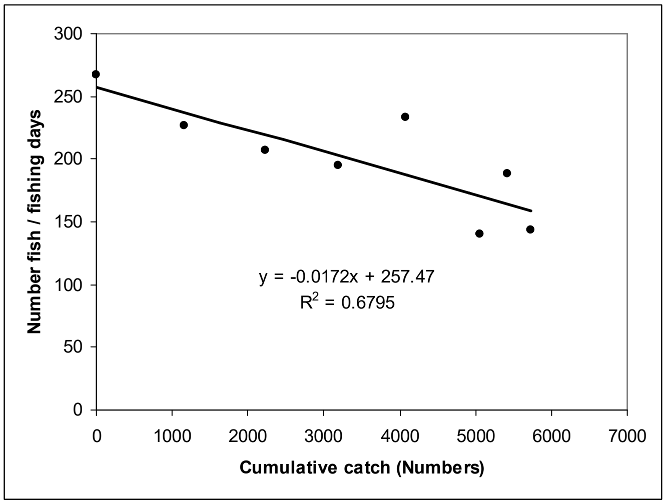
Basic Depletion Model

$$P_{t+1} = P_t - C_t$$



- Data Requirements
  - Time series of catch in numbers
  - Index of abundance

Example Fishing Experiment



$$P_t = P_0 - \sum_{i=0}^{t-1} M_t$$

PRODUCTION MODELS

Logistic Model

$$\frac{dB}{dt} = rB\left(1 - \frac{B}{B_\infty}\right)$$

$$B_t = \frac{B_\infty}{1 + \left(\frac{B_\infty}{B_0} - 1\right)e^{-rt}}$$

Continuous Form

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

Discrete Form: Used in stock assessment.
B_0 required

$$C_t > rB_t\left(1 - \frac{B_t}{B_\infty}\right)$$

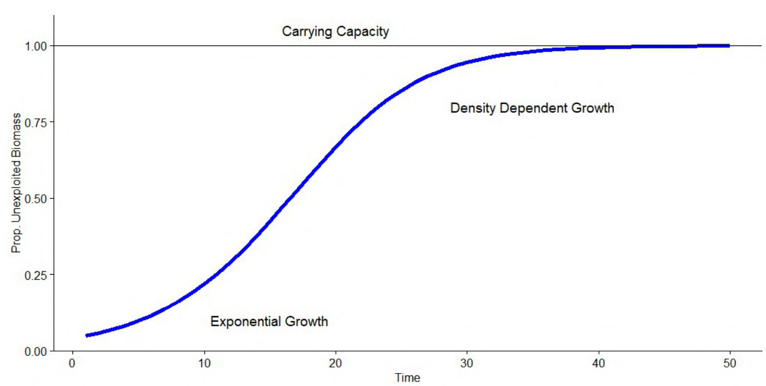
Population declines

$$C_t < rB_t\left(1 - \frac{B_t}{B_\infty}\right)$$

Population recovers

Production Model

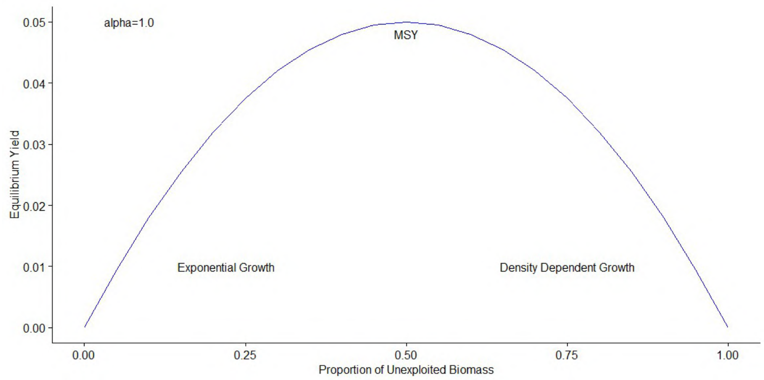
- Production models describe the growth of a population
- Population growth is exponential when the population is low
- Population growth is limited by a carrying capacity
- Pella-Thomlinson general model form alters where MSY is in relation to biomass
- We will use the Schaefer model in the training below (i.e. $\alpha = 1$)
- The model requires four parameters are needed: B0, r, Binf (B_∞) and α
- This model should be considered an empirical description of the response of a population to harvesting rather than a model of actual population processes such as growth and recruitment.
- $B_{t+1} = B_t + \frac{rB_t}{\alpha}\left(1 - \left(\frac{B_t}{B_\infty}\right)^\alpha\right)$



In JABBA: m = α-1

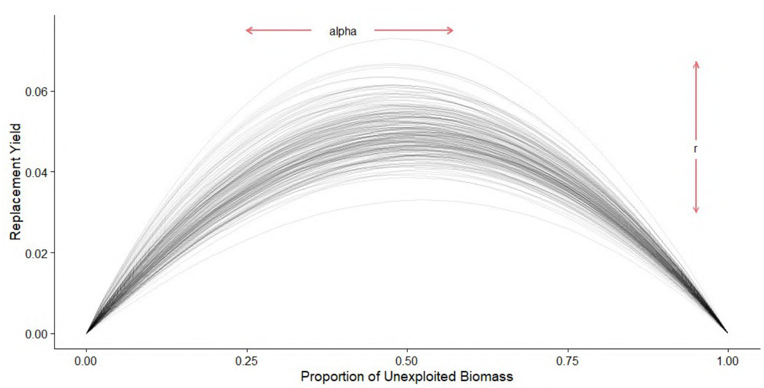
Yield Curve

- The yield curve is the theoretical growth of the population
- The yield depends upon population (biomass) size
- Maximum Sustainable Yield is the point growth is fastest
- If the catch is equal to the population growth, the population will not change



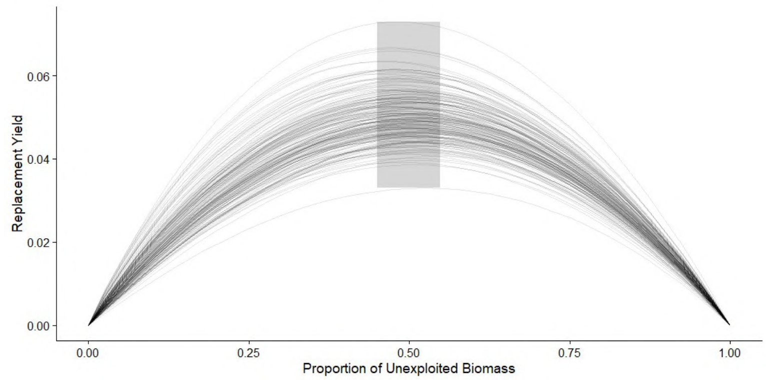
Sources of Uncertainty

- The parameters may be estimated but not known exactly
- The yield can vary with the parameter r and B_∞
- The B_{MSY} point varies with α
- Parameters are often difficult to estimate



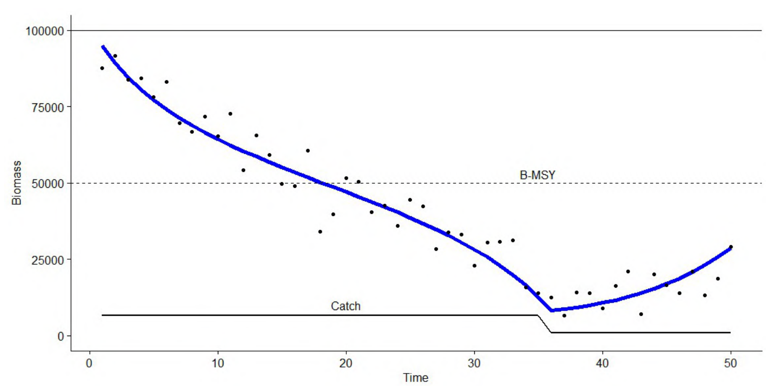
Setting Management Controls

- Significant uncertainty setting Total Allowable Catches (TAC)
- If TAC > MSY, stock will decline and it will not be sustainable (related to r and B_∞ uncertainty).
- Effort control more robust to uncertainty, but has problems with improving efficiency.
- Best option: robust precautionary feedback system is required while information improves.



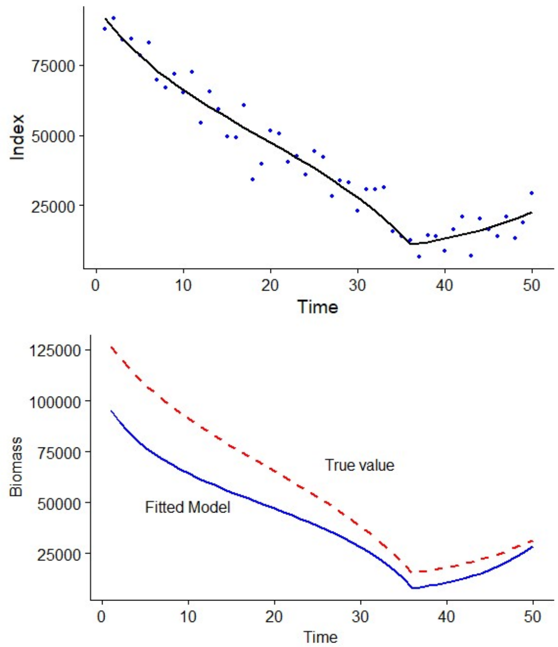
Fitting to Data

- Often we have TOTAL CATCH and one or more ABUNDANCE INDICES.
- Total catch must be ALL removals
- Abundance indices can be fishery-independent survey based or fishery standardised CPUE, but should be proportional to population size (biomass).
- We can run a simulation to show how / whether the model fits.



Model Fitting

- It is better to avoid any of the old equilibrium fitting methods. They are not necessary because it is easier to fit a dynamic model.
  If we fit to this "toy" example, we get a reasonable fit to the data.
  Four parameters are needed: B_0, r, B_∞ and q.
- The fit is based on minimising a sum-of-squared-difference score - "least squares".
  There is a clear bias in the estimate of absolute abundance (143 %)
- The MSY is estimated as 4154 compared to the true value of 5000

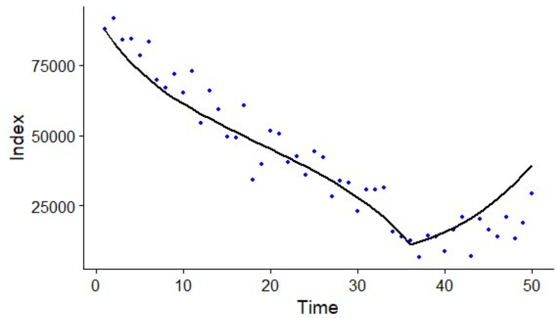


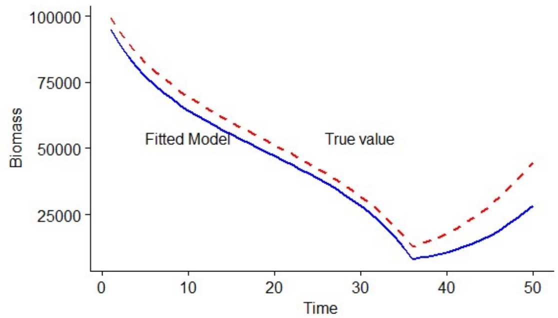
Estimation: What went wrong?

- Nothing went "wrong", but we cannot expect non-linear models to necessarily provide good estimates without help.
- Estimates are not disastrous and are precautionary, but this cannot be guaranteed.
- In this case, the situation was perfect. Catches were known exactly. A well-behaved abundance index were used with only observation error. The data were simulated with the same model as was fitted. A different set of random numbers could produce better or worse result.
- To improve this, we can:
  – add additional information in the form of priors or penalties to aid the fitting.
  – fully account for the uncertainty so that this can be taken into account with the decision-making.

Priors

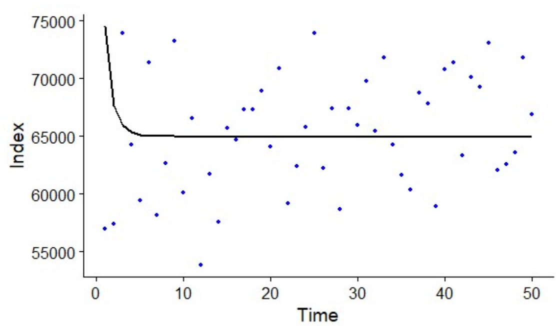
- It is possible to fix parameters, but this is not recommended. Instead we put a penalty function on parameters that encourages the parameter to be close to the value we think that it should be, but allow the data to support any differences to our PRIOR expectation.
- For example, say that we thought the r parameter was around 0.2, rather than the estimated 0.046, based upon what we know of the life history. Similarly, we know there was not much fishing before the start of the time series. We could propose a penalty function that increases the overall sum-of-squared-difference score for these parameters.
- The penalty function is based on the normal distribution and is therefore also a squared difference between our expectation and the parameter value.
- Independent priors on parameters are particularly good at dealing with parameter correlation, where information in the data cannot distinguish between combination of estimates. For example, parameters B_∞ and q are often correlated, so a high B_∞ and low q are identical in terms of fit to a low B_∞ and high q.
- As can be seen, the addition of priors leads to a much better fit. But the priors were constructed around the true values. Of course in reality, we never know what those true values are.

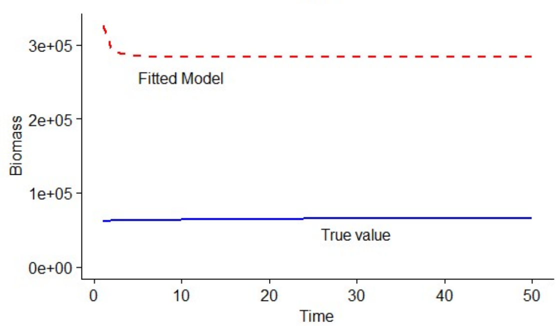




Time Series

- There are other problems with fitting the model related to the data.
- This type of model explains how a population responds to depletion, so it really needs to fit to one or more depletion events to work. If there are no such events, the data provide no indication of the decline and recovery rates relative to the catch.
- To illustrate this, we try to fit the model with very weak (uninfluential) priors.
- The model fits the abundance indices well, but parameter estimates are heavily correlated and fitting may well fail without priors.
- The MSY is estimated as 47608 compared to the true value of 5000, which would be a disaster if used naively in management advice.
- The parameter r is particularly overestimated in this case, but more generally the uncertainty around all parameters is greatly increased.



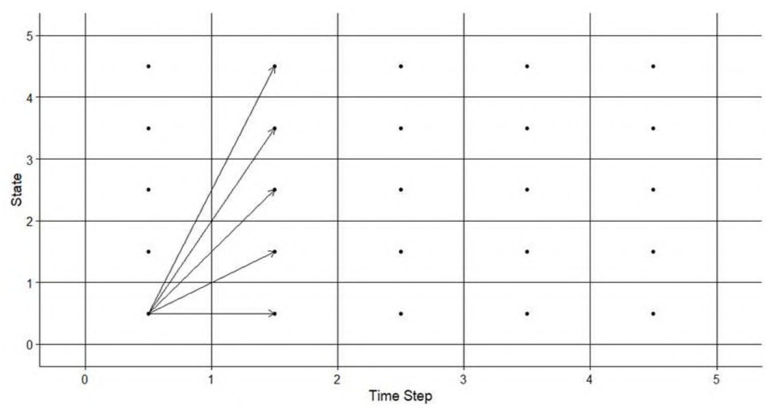


Process Error

- Production models are a very simple approximation of reality.
- In the form above, production models do not account for PROCESS error, only OBSERVATION error, which is the difference between an observed abundance index value and the expected value given the true abundance.
- Observation error only affects the single estimate and does not affect any observations before or after.
- Process error accounts for intrinsic uncertainty in the population dynamics, such as variability in recruitment from year to year.
- Process error can affect future population sizes beyond the year in which it occurs. So a strong or weak recruitment will affect a population for the lifespan of that cohort as it ages through the population.
- Fundamental to the idea of process error is the concept of a LATENT variable, which cannot be observed directly. In our case, the latent variable is the population biomass which we indirectly observe through the abundance index and catch.

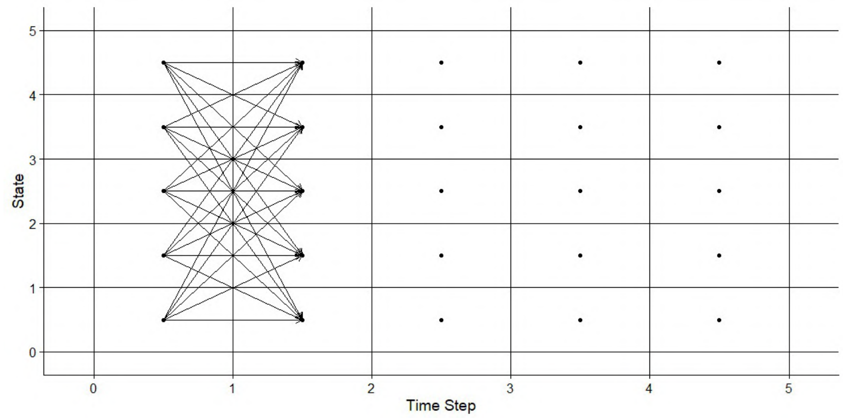
Simple Example: Markov Process

- Here we have 5 states over 5 time steps represented as a grid.
- Each "state" captures all information about something e.g. fish population size.
- A state-space model defines how, from step to step, the states transition between each other.
- Each transitions occur with a probability, and that probability is defined by a model.



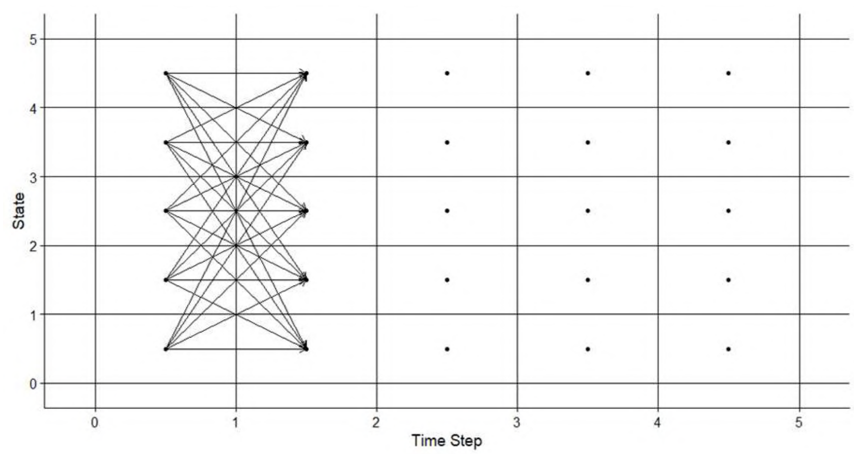
Transitions

- The model defines every transition from one state to another.
- We usually do not know the start state, so every state has to be considered.



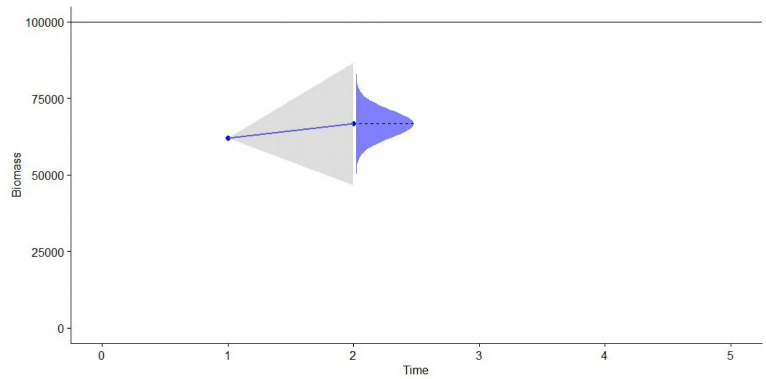
Time Sequence

- Then the model defines how a state is likely to change over time



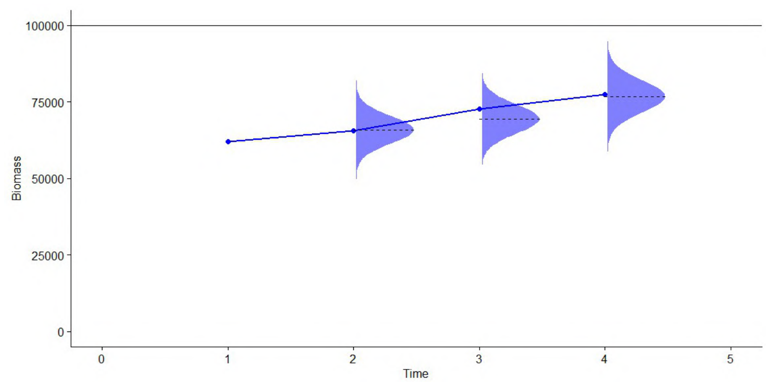
Fisheries Application

- In fisheries populations, we usually have a discrete time step as for our simple model above, but continuous states.
- As the number of states becomes very large, it is easier to deal with continuous quantities rather than discrete numbers.
- (Consider how many combinations of state change there would be with 1000000 fish)
- In the continuous state, the transition is represented as a probability density function.



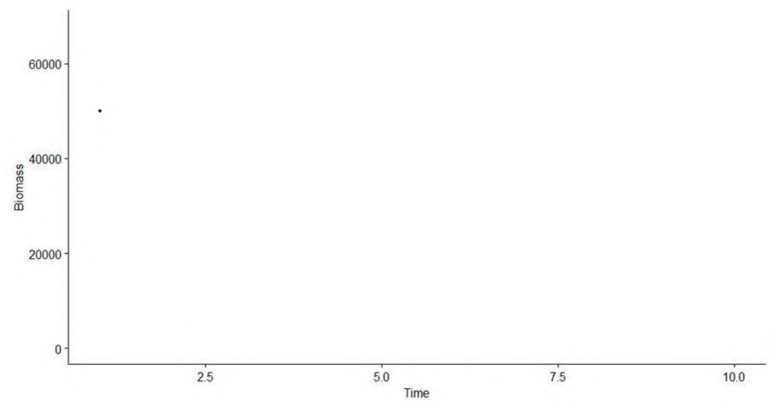
Realization of A Population Process

- The probability density function shows the probability for each population size based on the actual previous population.
- Each actual population is a random draw from this probability density.



Simulation

- In this simplified example we show how a population with random recruitment might progress.
- Biomass (y-axis) is the "state" of the process.
- Each time step in this graph each biomass has two random growth states which are followed.
- This shows possible biomass paths through time, each one being equally likely.
- However, we want an effectively an infinite number of paths, not just two. But this is too complex to model in this way.

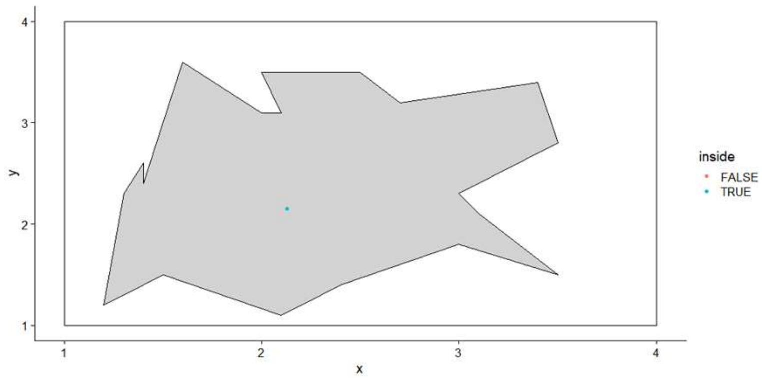


Fitting State Space Models

- In a state space models, each state is occupied with a probability and transition to every other state is also governed by a probability (a stochastic process population dynamics model).
- These stochastic states and process error are difficult to deal with in fisheries models. You (usually) cannot simply fit stochastic models as they require too many parameters that are correlated ("aliased") or are unsupported by the data.
- To help solve this, we generally sum over all possible population states according to their probability. This "integrates out" possible states simplifying the results.
- Integrating complex functions like this is done using numerical techniques.

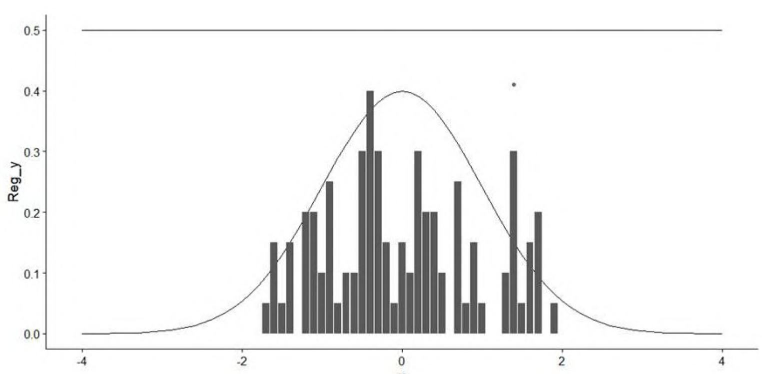
Monte Carlo Integration

- Monte Carlo simulations are used as a robust way to solve a number of problems, including integration of functions
- Analytical integration is not possible for many practical purposes
- Numerical integration is possible using different methods
- Monte Carlo integration is the most flexible way and works with “difficult” functions such as likelihoods.
- For example, we can estimate the area of any irregular 2D shape by:
- Drawing a regular shape around it for which we know the area (A)
- Choosing N random points within the regular shape
- Counting the number within the irregular shape (n) so the area of the irregular shape is: A*n/N
- The larger N is, the more accurate our estimate will be.



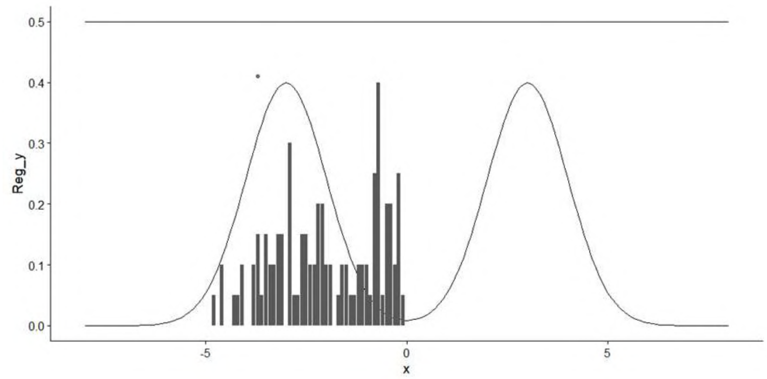
Markov Chain Monte Carlo

- “Markov Chain Monte Carlo” is a Monte Carlo numerical integration techniques
- The advantage of MCMC is that it can work with any number of parameters (dimensions) and with very complicated functions
- MCMC does not work all the time. Sometimes it converges too slowly to be useful.
- The animation provides a very simple example:
- The dot randomly moves between x’s but only one step at a time.
- Each step is accepted or not in proportion to the relative height of the curve and the horizontal straight line.
- If accepted, the move is completed and the x value added to the histogram.
- If not accepted the dot does not move.



MCMC Problems

- MCMC is subject to many problems. Although it is a very powerful technique, within complicated posterior functions that may have more than one mode, the MCMC can fail to explore the full function adequately.
- To test this and make sure the MCMC has "converged" (covered all regions appropriately), several parallel chains are run and compared. If they all give the same answer, the MCMC is probably correct.
- But in practice, there is some reliance on the likelihood being "well-behaved" and some effort may be required to ensure this.



Just Another Gibbs Sampler (JAGS)

- A Gibbs sampler rotates through each parameter deciding whether to change it, or not
- Because it does (mostly) one parameter at a time, it makes it a simple approach, but does not work well all the time.
- However, it has probably been used the longest, and very good software is available to implement it, notably JAGS
- There is a free library you can download to use MCMC on your model that uses very sophisticated techniques to improve the MCMC

Just Another Bayesian Biomass Assessment (JABBA)

- JABBA uses JAGS to fit the state-space biomass dynamics (production) model
- Installation includes the 1) JAGs library 2) the JABBA R package
- The model can be fitted in R in 2 stages: 1) prepare the data and priors object 2) fit the model using this object
- The model must be evaluated and rejected if it does not fit well
- All outputs include uncertainty intrinsically, so this should be reflected in tables and graphs where possible

CPUE Standardisation: Why?

- Indices of abundance are often the most influential part of an assessment—invest accordingly. (Hoyle et al. 2024)
- The objective of standardisation is to remove variation in CPUE that is not due to changes in the population size.
- Changes in CPUE can occur because:
  - Improving (or rarely worsening) gear and operations
  - Differences among vessels and crew
  - Changes in management controls
  - Fishing in different at different times

CPUE Standardisation: Best Practice

- **Defining fleets is key.** Definitions depend on stock and fishery structure.
  a. **Plot everything.** Explore and understand data (catch, effort, CPUE, sizes, ages, maturity, gear types, logbook types, vessel turnover, misreporting, etc.).
  b. **Talk to fishers and other stakeholders.**
- **Identify likely covariates** before you start modelling. Avoid data dredging.
- **Differentiate between catchability and density variables**.
- **Structural changes based on understanding the system can be very important for the assessment**, whereas many other issues just cause small changes in the index trends.
- **Always include the variables that affect catchability** – this is usually more important than the type of model you use. Think about potential for bias due to missing variables.
- **Consider targeting and target change** through time and how to address it. Understand the fleet well enough to know what the targeting strategies might be.

JABBA Stock Assessment

Pomfret Stock

Paul A H Medley

2025-03-23

Abstract

A Bayesian state space production model (JABBA) is fitted to the available catch and effort data to estimate MSY related reference points, establishing stock status risks and in order to develop management advice. The results are...

Contents

1. JABBA Model and Data Requirements

JABBA (Winker, Carvalho, and Kapur 2018) is a standard state-space biomass dynamics model following the Pella-Thomlinson form (Pella and Tomlinson 1969). The model is very flexible and deals well with data-limited assessments.

Accurate total catches are required for biomass dynamics models. These should include all the fisheries related mortality from commercial, industrial, artisanal, subsistence and recreational fishing. Only the trawl fishery catch data were available.

The abundance indices used are the available CPUE which are separated in indices for each of the main gear. Auxiliary indices can also be included in the JABBA model. An estimate of the level of depletion was obtained from the length-based catch curve model which was incorporated in the JABBA stock model as an auxiliary index of B/B_{MSY}.

2. Total Catch and Catch Effort Data

Total catches will need to be defined for as long a time series as possible. Any gaps in total catch or missing catch will be needed as estimates or guesses.

A CPUE series has been made available. The more complete this series is the better, but missing data does not have to be provided.

The data are plotted.

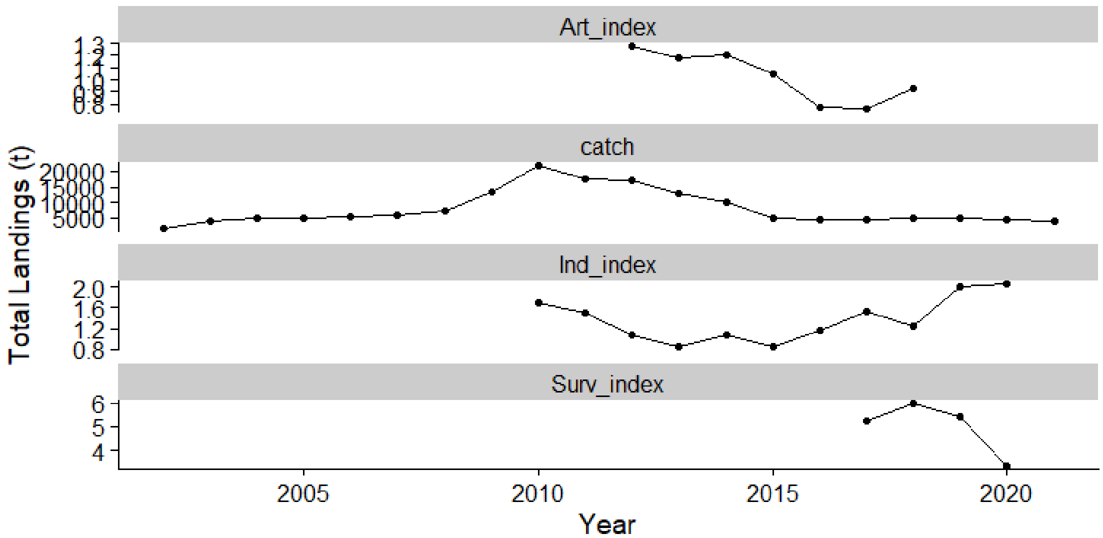


Figure 1: Total annual landings and CPUE

3. Base Model

The JABBA model is fitted to the available data and the result plotted against observed catch and abundance indices. Various standard plots are provided by the JABBA package, but additional plots and tables may be developed as the output of functions.

The following will need to be considered when fitting this model:

- the priors on the initial state of the stock, r and K.
- the data series that will be used. Total catch will always be required, and at least one CPUE series.
- the time step (usually 1 year, but may be lower for short-lived species)
- the model type to be fitted: Schaefer, Fox or Pella-Thomlinson

The runs test {Passed, Failed, Passed} (p = {0.839, 0.02, 0.11}).

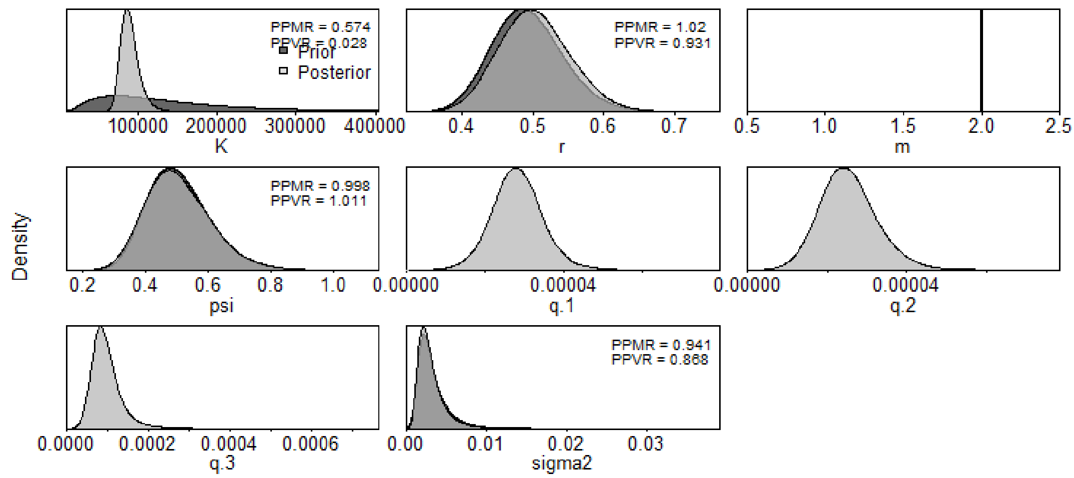


Figure 2: Prior and posterior density plots for the base model.

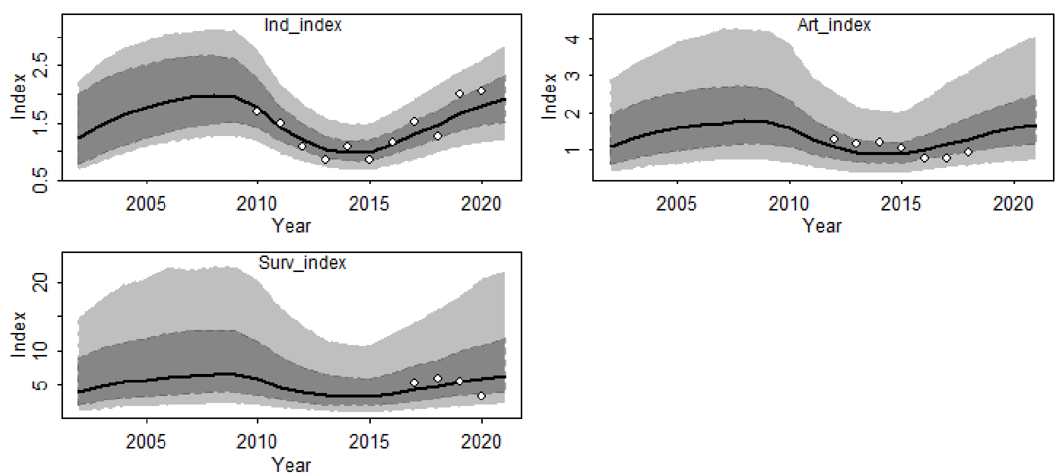


Figure 3: CPUE fits for the base model.

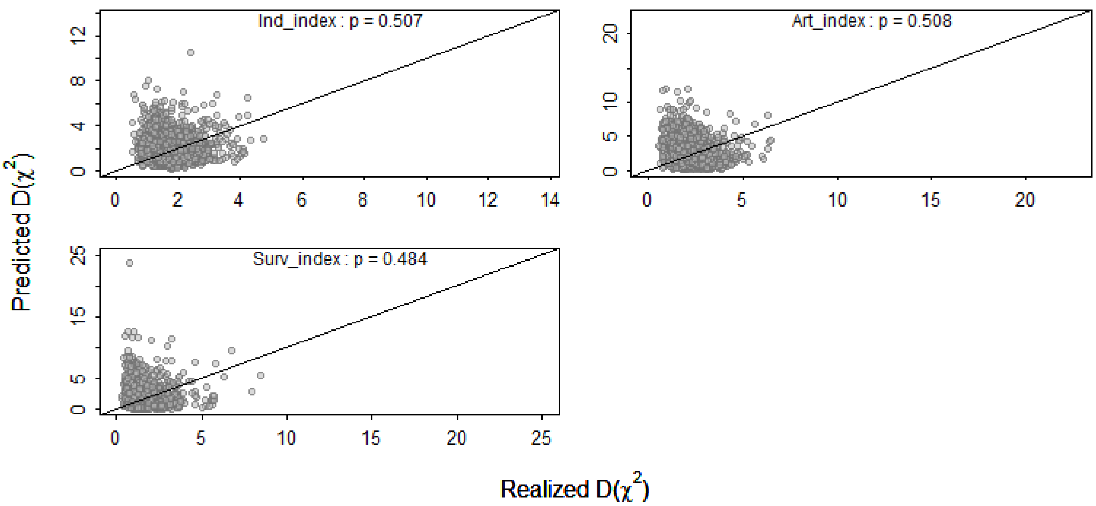


Figure 4: Posterior predictive checks for the base model.

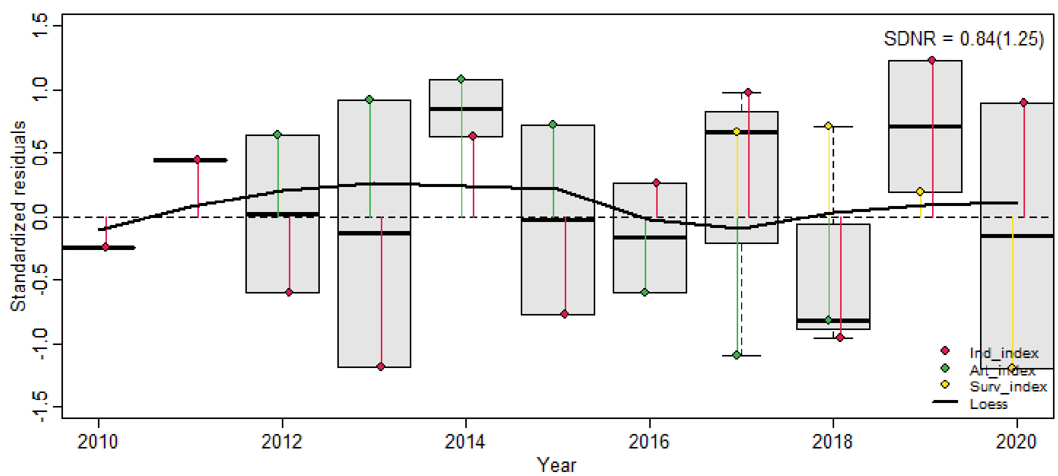


Figure 5: Standardised residual plots for the base model.

4. Conclusion

Summary of conclusions from the stock assessment...

Table 1: Summary of results for the base model.

Scenario	Par	Estimate
Base Model	K	89,000.239

Base Model	r	0.500
Base Model	psi	0.498
Base Model	sigma.proc	0.051
Base Model	m	2.000
Base Model	Hmsy	0.250
Base Model	SBmsy	44,500.120
Base Model	MSY	11,127.228
Base Model	bmsyk	0.500
Base Model	P2002	0.497
Base Model	P2021	0.782
Base Model	B_Bmsy.cur	1.564
Base Model	H_Hmsy.cur	0.231

5. References

Pella, Jerome J., and Patrick K. Tomlinson. 1969. "A Generalized Stock Production Model." http://hdl.handle.net/1834/21263.

Winker, Henning, Felipe Carvalho, and Maia Kapur. 2018. "JABBA: Just Another Bayesian Biomass Assessment." *Fisheries Research* 204 (August): 275–88. https://doi.org/10.1016/j.fishres.2018.03.010.

A Length-Based Catch Curve for Multigear Fisheries

Paul A Medley (paulahmedley@gmail.com)

Motivation

- Use all length frequency data (as LBSPR)
- Bayesian fitting
- Allow flexible selectivity functions and multiple gears

Assumptions

1. **The population has been in an approximate steady-state for a generation or more around when the length sampling takes place (No time series).**
2. Mean growth follows the von Bertalanffy growth curve.
3. Fish asymptotic size (L_∞) is Gamma distributed for individual fish which governs growth variability.
4. Mortality fixed within each length interval. It can vary arbitrarily between intervals.
5. **Length data are representative of the catch length composition and the relative total catch numbers for each selectivity group.**

MODEL DESCRIPTION

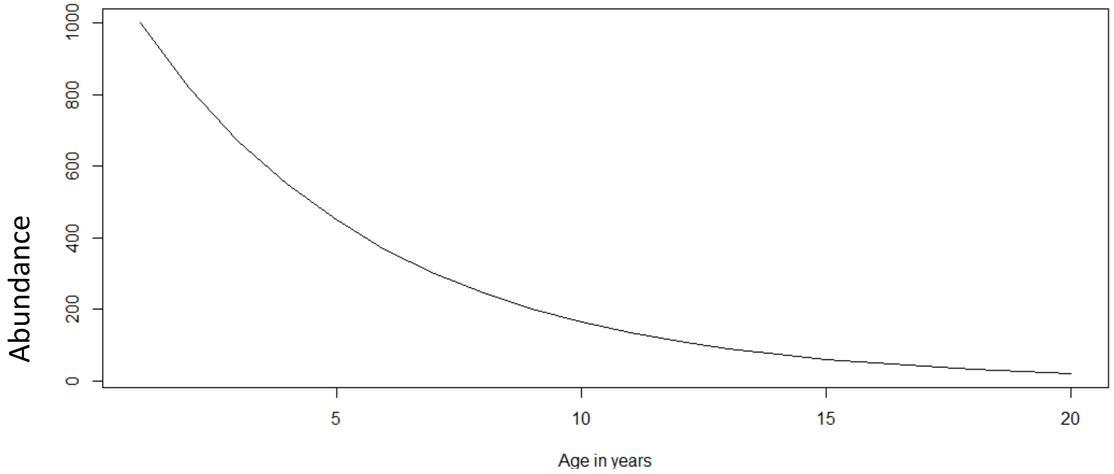
Age-based Catch Curve

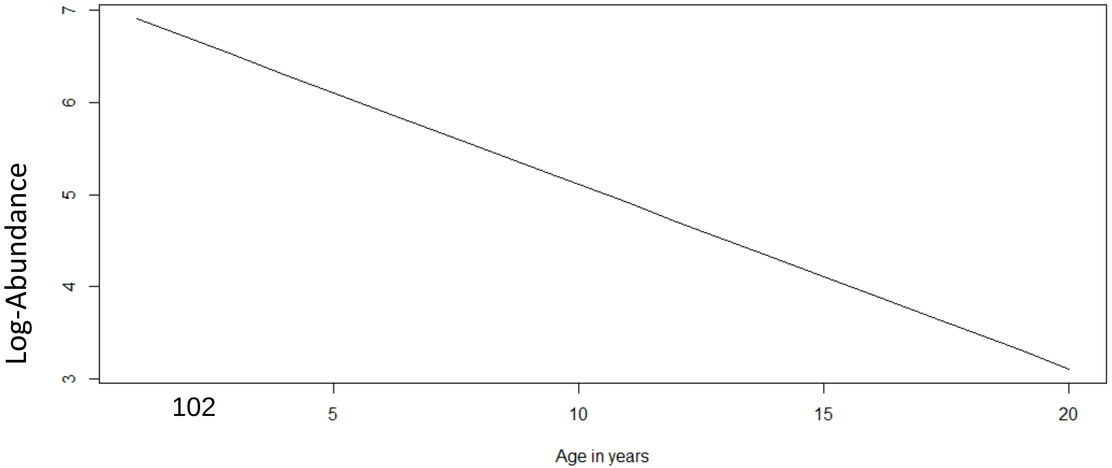
Catch curves are based on the idea that cohorts of fish (all fish with the same age) reduce at a fixed mortality rate over time.

If we follow a single cohort of fish, this decline in numbers would be exponential.

For example, a cohort of 1000 fish from age 1 with around 20% mortality (Z=0.2).

But same form for abundance index



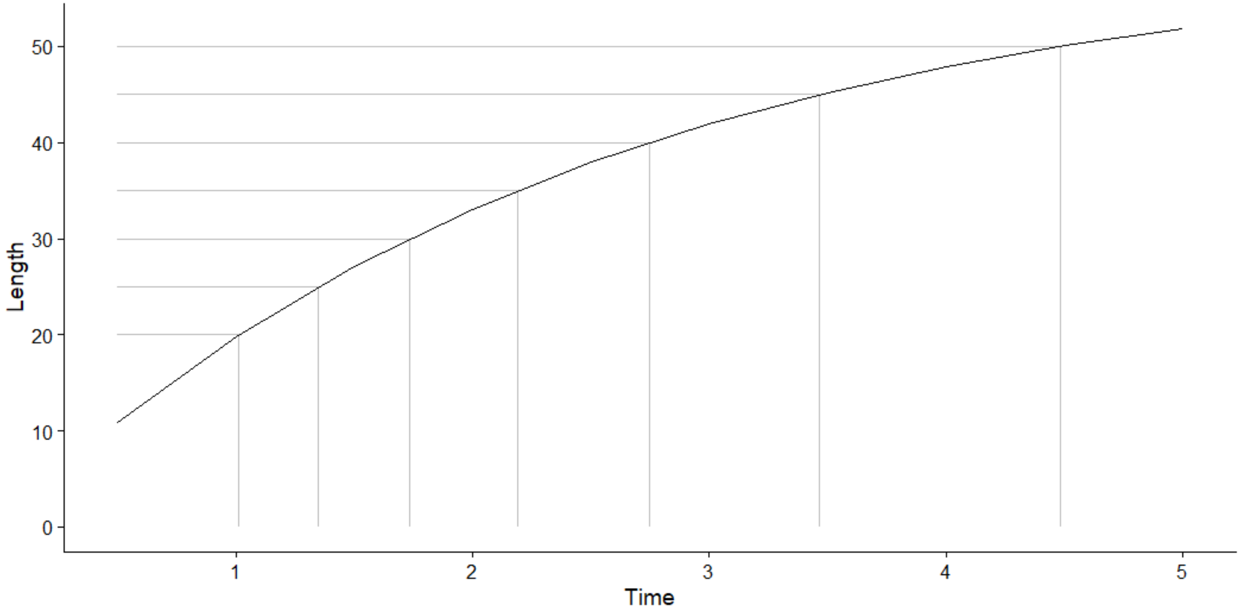


vB Growth: Transition Times

The transition time across a length interval i in time units of growth rate parameter K is:

$$t_i = \mathrm{K}\,(a_{i+1} - a_i)$$
$$= log\left(\frac{L_\infty - L_i}{L_\infty - L_{i+1}}\right)$$

As the length increases, the time difference between sequential length intervals also increases due to the growth function.



Interval Mortality

Given its asymptotic length and a fixed mortality rate ($Z/\mathrm{K} = Z_k$,(the probability for survival for an individual fish passing through a length bin is:

$$e^{-Z_k \mathrm{K} t_i} = NA \qquad L_\infty \le L_i$$

$$e^{-Z_k \mathrm{K} t_i} = 0 \qquad L_i < L_\infty \le L_{i+1}$$

$$e^{-Z_k \mathrm{K} t_i} = \left(\frac{L_\infty - L_i}{L_\infty - L_{i+1}}\right)^{-Z_k} \qquad L_{i+1} < L_\infty$$

Survival Model

If the mortality can be defined for sequential length intervals each with a fixed mortality, the survival for particular fish starting at length L_0 to length L_n can be defined as the product of surviving each interval between:

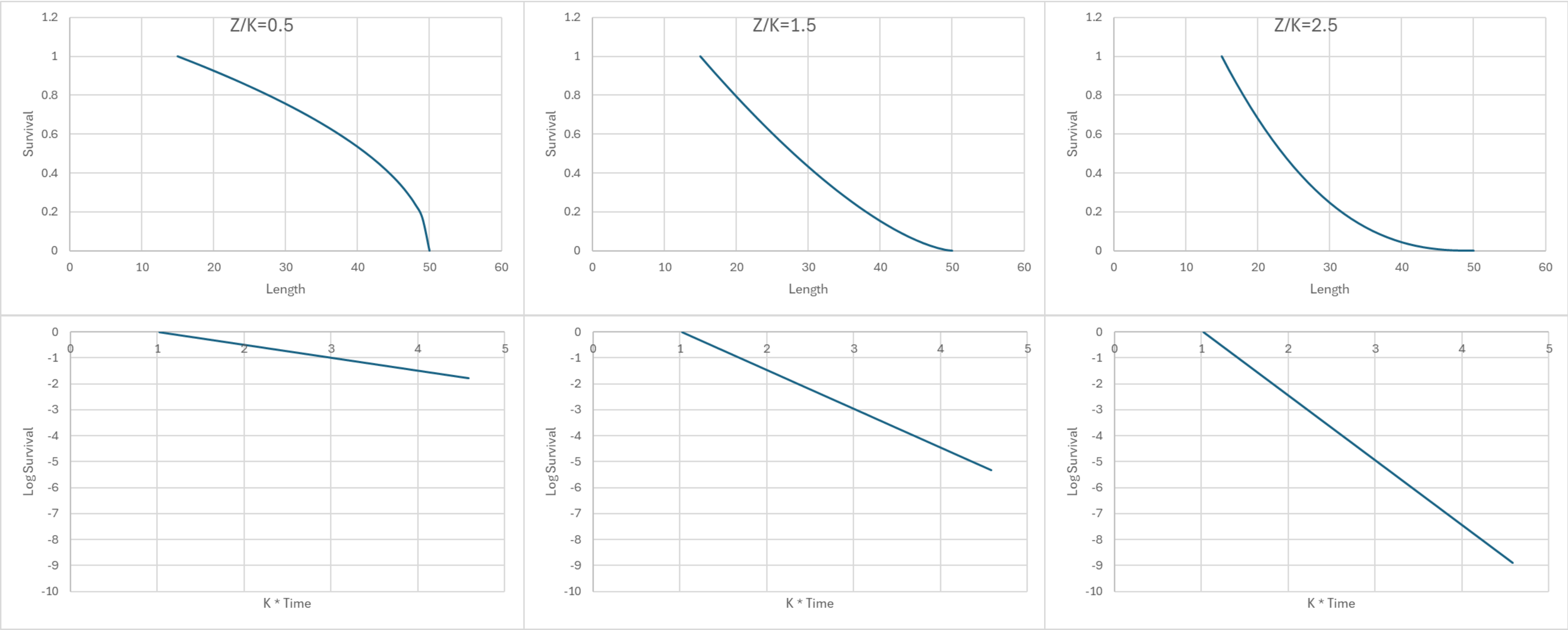
$$S_n = \left(\frac{L_\infty - L_0}{L_\infty - L_1}\right)^{-Z_1} \left(\frac{L_\infty - L_1}{L_\infty - L_2}\right)^{-Z_2} \ldots \left(\frac{L_\infty - L_{n-2}}{L_\infty - L_{n-1}}\right)^{-Z_{n-1}} \left(\frac{L_\infty - L_{n-1}}{L_\infty - L_n}\right)^{-Z_n}$$

$$= (L_\infty - L_0)^{-Z_1} (L_\infty - L_1)^{Z_1 - Z_2} (L_\infty - L_2)^{Z_2 - Z_3} \ldots (L_\infty - L_{n-1})^{Z_{n-1} - Z_n} (L_\infty - L_n)^{Z_n}$$

$$= (L_\infty - L_0)^{-Z_1} (L_\infty - L_n)^{Z_n} \prod_{i=1}^{n-1} (L_\infty - L_i)^{Z_i - Z_{i+1}}$$

Age vs Length Based Catch Curve

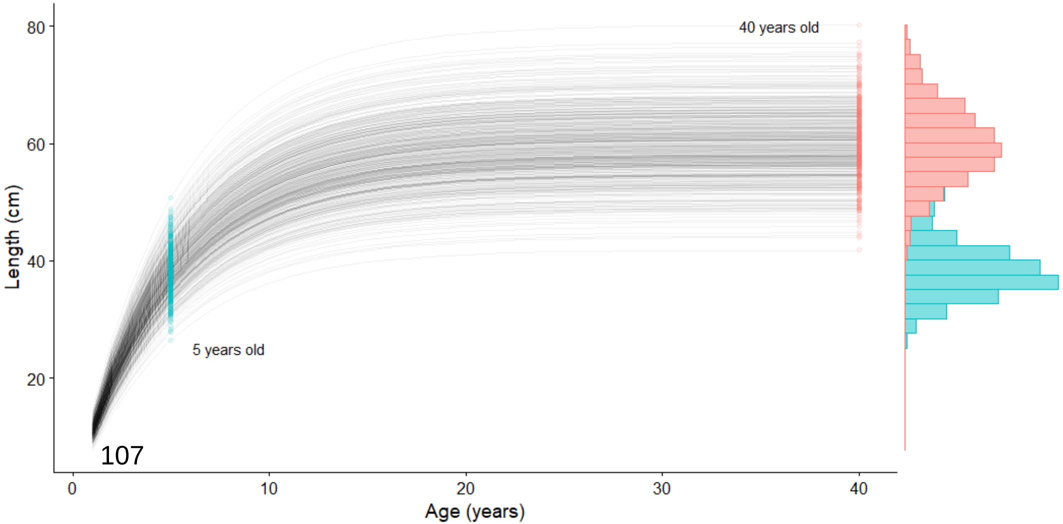
Fixed Z/K



Gamma Growth Variation

$$\Pr(L_\infty) = \frac{\beta^\alpha}{\Gamma(\alpha)} L_\infty{}^{\alpha-1} e^{-\beta L_\infty}$$

- von Bertalanffy growth function.
- Each fish has its own L_∞, distributed as a Gamma variable.
- K is constant for all fish.
- The Gamma distribution describes the individual fish asymptotic length; has fixed coefficient of variation (CV) = $\frac{1}{\sqrt{\alpha}}$
- CV for length at age is usually 5%-30%, so $\alpha = [9{,}400]$ and $\beta = \alpha / \widehat{L_\infty}$ where $\widehat{L_\infty}$ is the mean asymptotic length for the species.



Population Model

The probability that fish will survive to length interval n with lower bound L_n is given by:

$$S_n = \int_{L_n}^{\infty} \frac{\beta^\alpha}{\Gamma(\alpha)} L_\infty{}^{\alpha-1}\ e^{-\beta\ L_\infty} (L_\infty - L_0)^{-Z_1}\ (L_\infty - L_n)^{Z_n} \prod_{i=1}^{n-1} (L_\infty - L_i)^{Z_i - Z_{i+1}}\, dL_\infty$$

Catch equation over the interval:

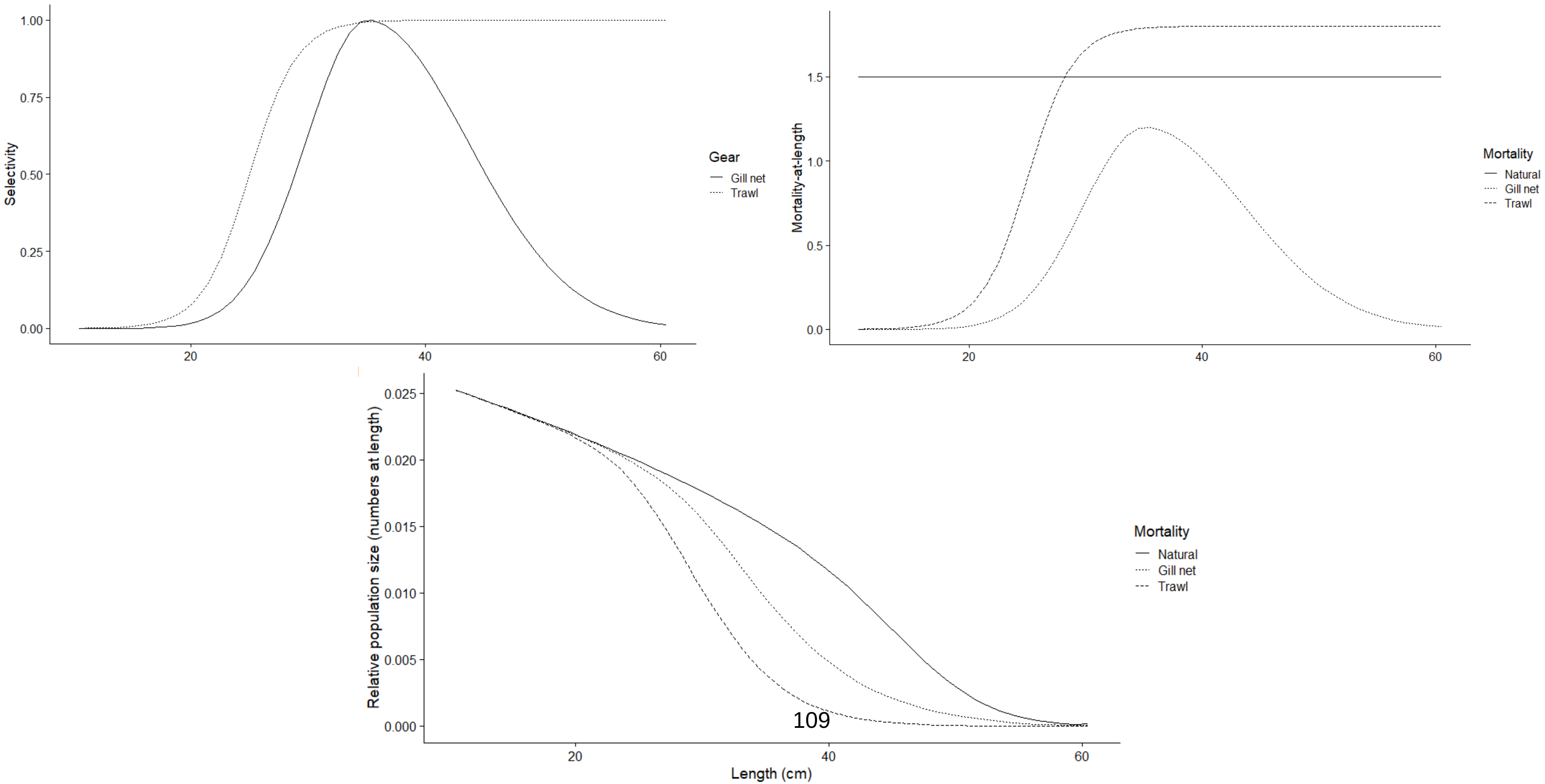
$$N_n = \frac{S_n - S_{n+1}}{Z_n}$$

$$C_{gn} = \frac{F_{gn}}{Z_n}(S_n - S_{n+1})$$

F_{gn} will reflect the selectivity pattern of Gear g.

Gauss-Laguerre quadrature is used for numerical integration (fast and accurate in this case).

Multiple Gears



APPLICATION: fishblicc

Application R package: *fishblicc*

- Work-In-Progress
- Implements Bayesian length-based catch curve (in Stan)
- Selectivity models based on **simple mixtures** of logistic, normal, single-sided normal and double-sided normal

- R Package: https://github.com/**PaulAHMedley/fishblicc**

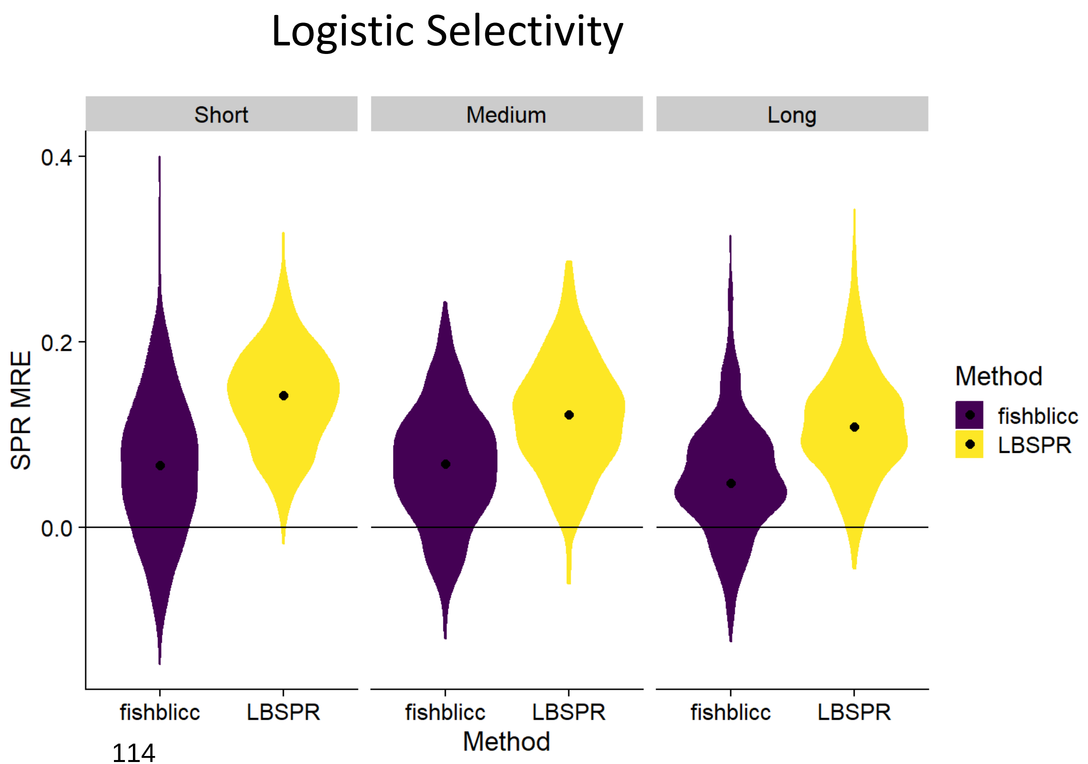
Priors

- Informative priors:
  - L_∞ is required - often available from Fishbase or elsewhere
  - Natural mortality: M ≈ 1.5 K
  - Growth CV (Galpha) - default 10%
  - K and t_0 not required
- Non-informative priors (usually)
  - Fishing mortality / selectivity parameters
  - Observation error

SIMULATION TESTING

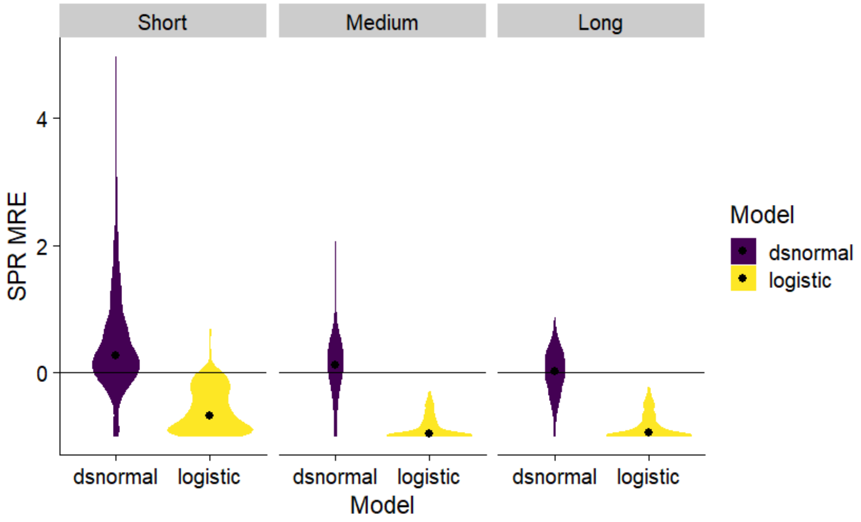
fishblicc vs LBSPR

- Chong, Lisa, Tobias K Mildenberger, Merrill B Rudd, Marc H Taylor, Jason M Cope, Trevor A Branch, Matthias Wolff, and Moritz Stäbler. 2019. "Performance Evaluation of Data-Limited, Length-Based Stock Assessment Methods." Edited by Emory Anderson. *ICES Journal of Marine Science* 77 (1): 97–108. https://doi.org/10.1093/icesjms/fsz212
- Individual Based Model for a fish population originally used to test ELEFAN
- 3 representative species
- Mean relative error for SPR for 500 simulations with monthly samples taken for the three life histories.

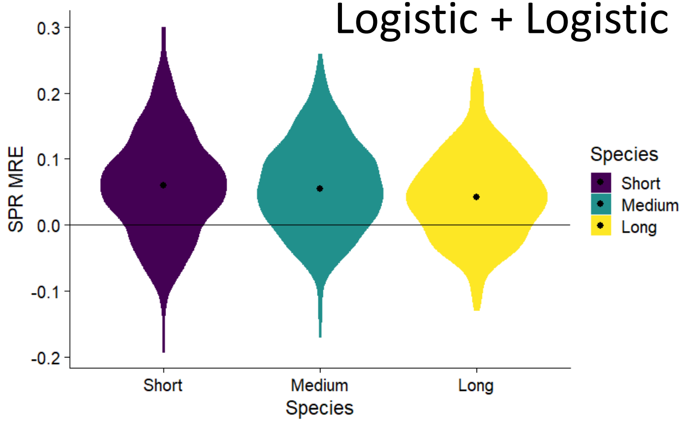


Multiple Selectivities

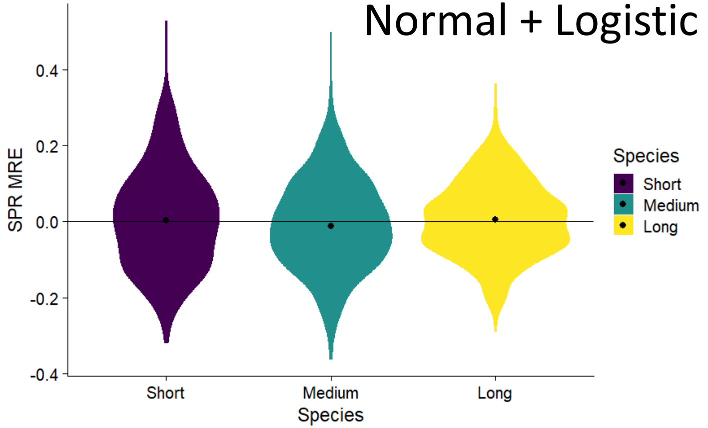
Double-sided normal selectivity



Logistic + Logistic

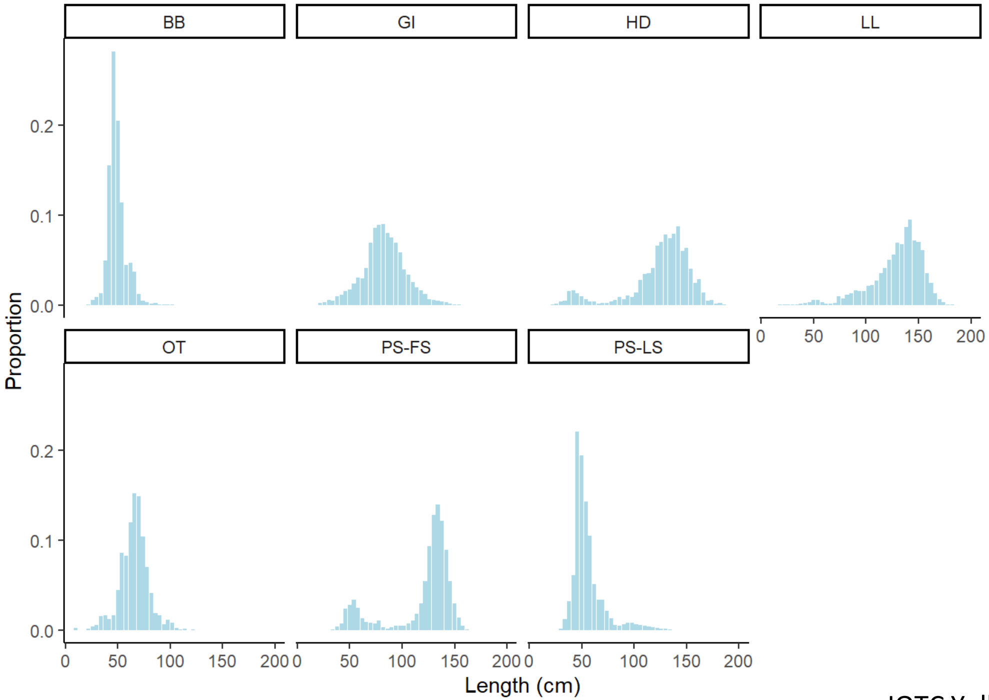


Normal + Logistic

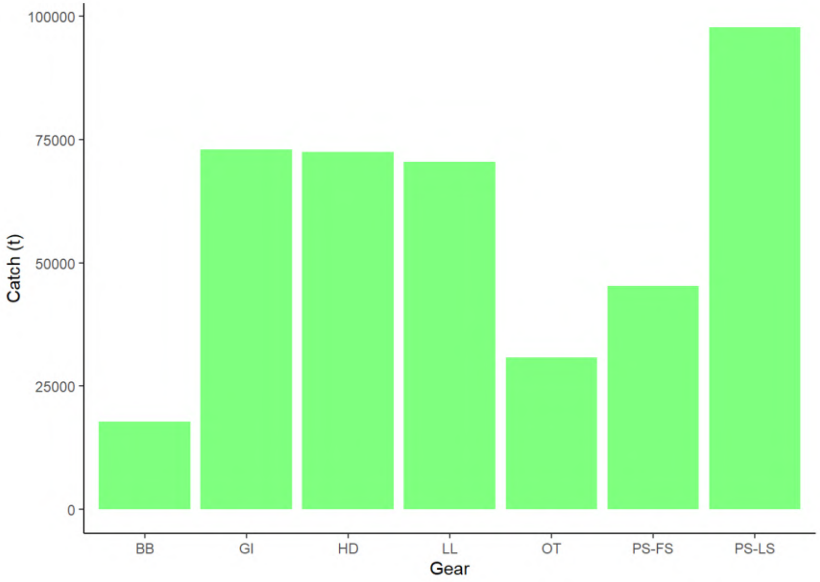


ILLUSTRATIVE EXAMPLE: IO YELLOWFIN

Yellowfin Length Frequency Data + Catches

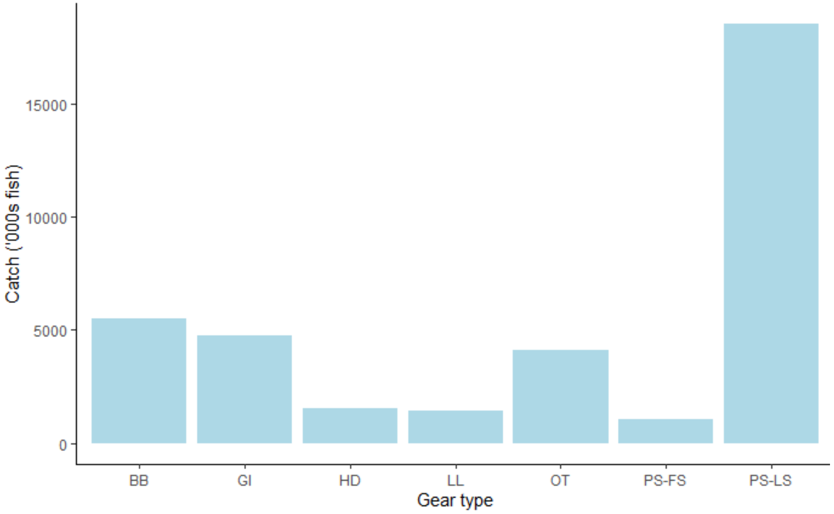


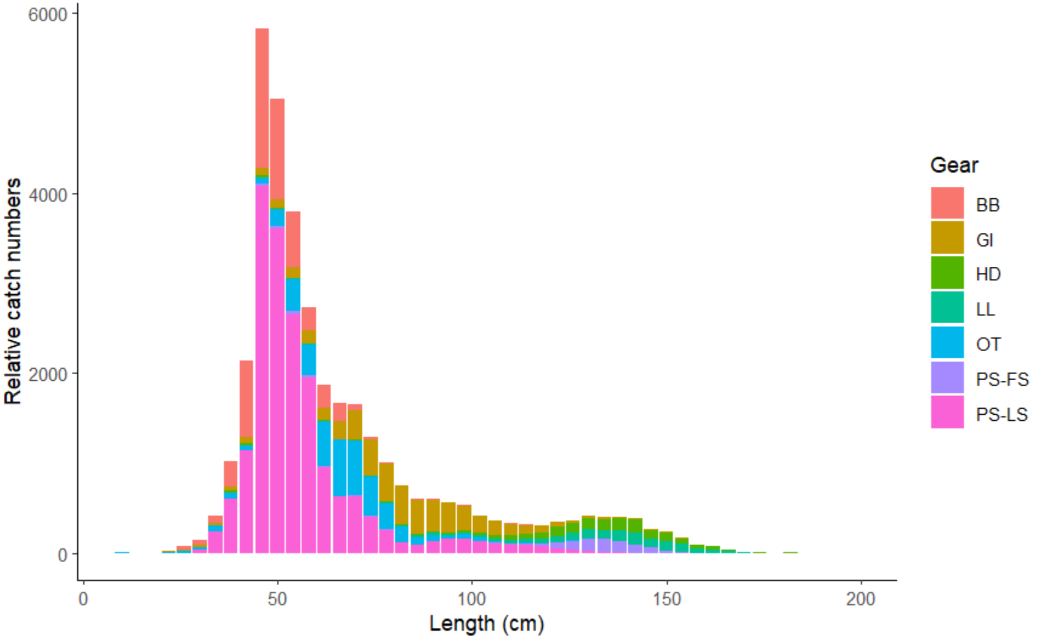
Aggregated 2014 – 2018



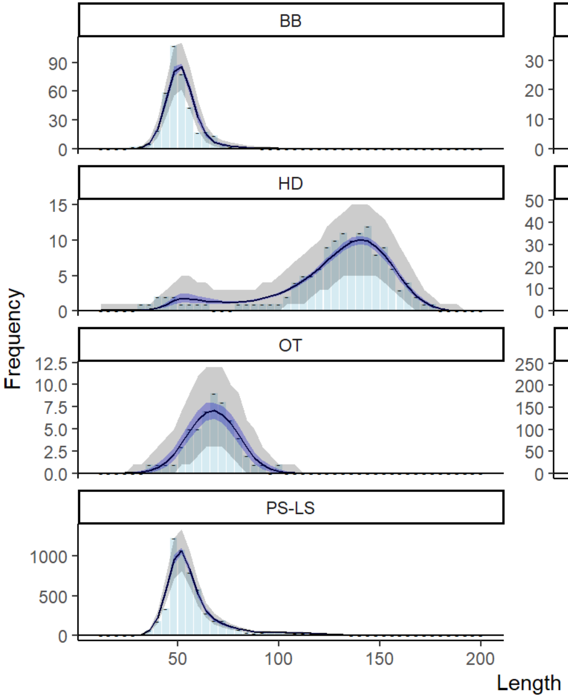
IOTC Yellowfin data used in the 2019 stock assessment SS3 V3.30
https://iotc.org/sites/default/files/documents/2019/09/IOTC-2019-WPTT21-DATA15-YFT_SA_0.zip#"Stock assessment inputs (SS3 and SCAA) for YFT"#"IOTC-2019-WPTT21-DATA15"

Catch Numbers



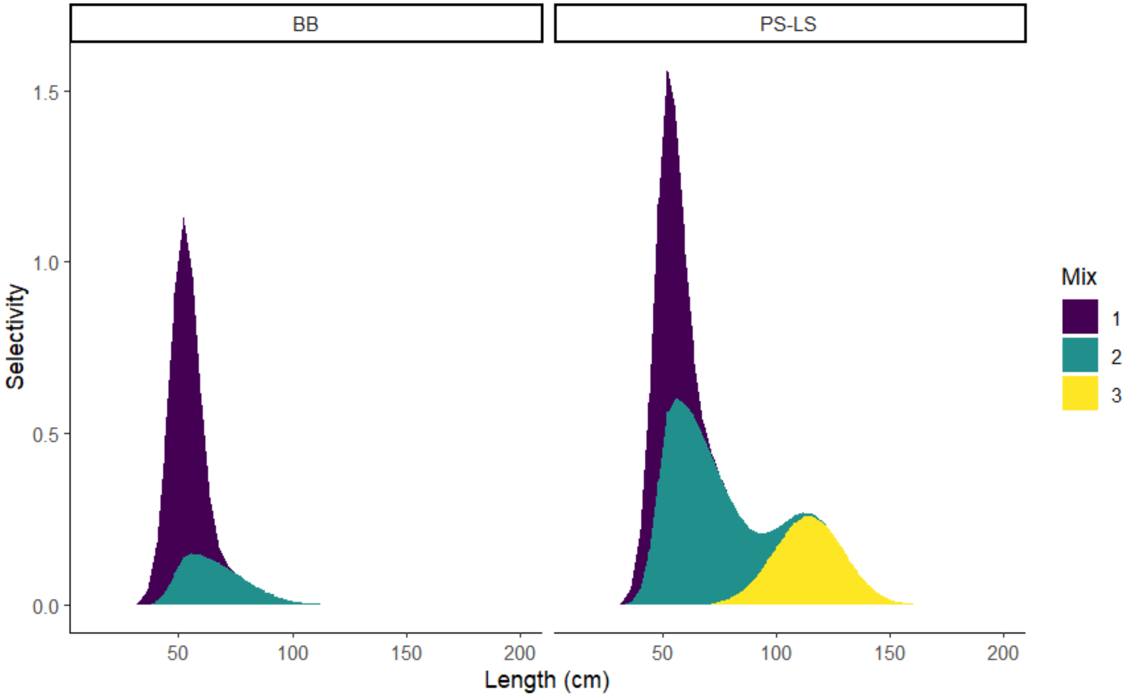


Fitted model



- Selectivity mixtures
- Length-inverse M
- Fishbase L_∞

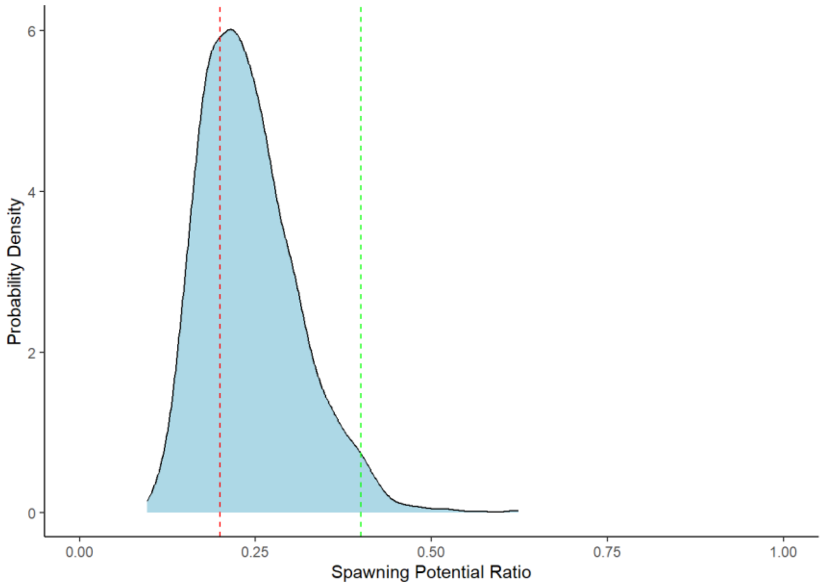
Selectivity Mixtures



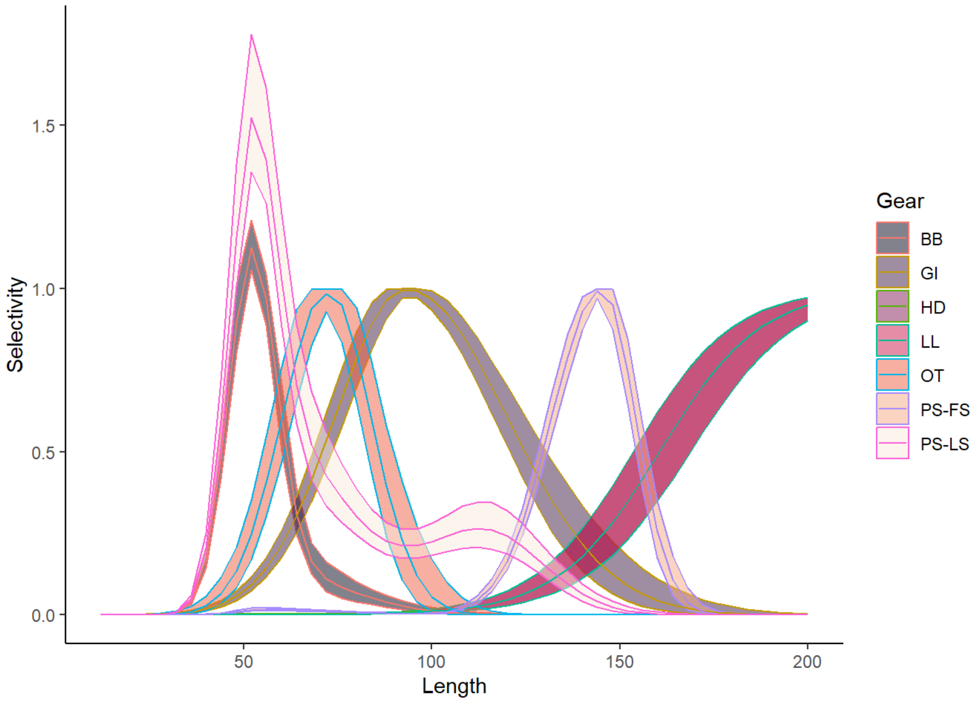
Model Flexibility

Scenario	L_∞	Galpha	M/K	SPR	lp	Decision
All domed single selectivity	166.67	73.17	4.00	0.80	-812.9	Rejected
Selectivity Mixture Model	179.06	133.28	1.61	0.21	-550.7	Accept
Allow Linf estimation	160.44	170.07	1.50	0.61	-549.6	Sensitivity
Length-inverse M	178.87	123.84	1.68	0.23	-547.6	Accept
Longline dome-shaped	184.30	98.14	1.48	0.80	-559.3	Rejected
SS3 parameters	148.16	164.54	0.73	0.48	-537.1	Sensitivity

Results



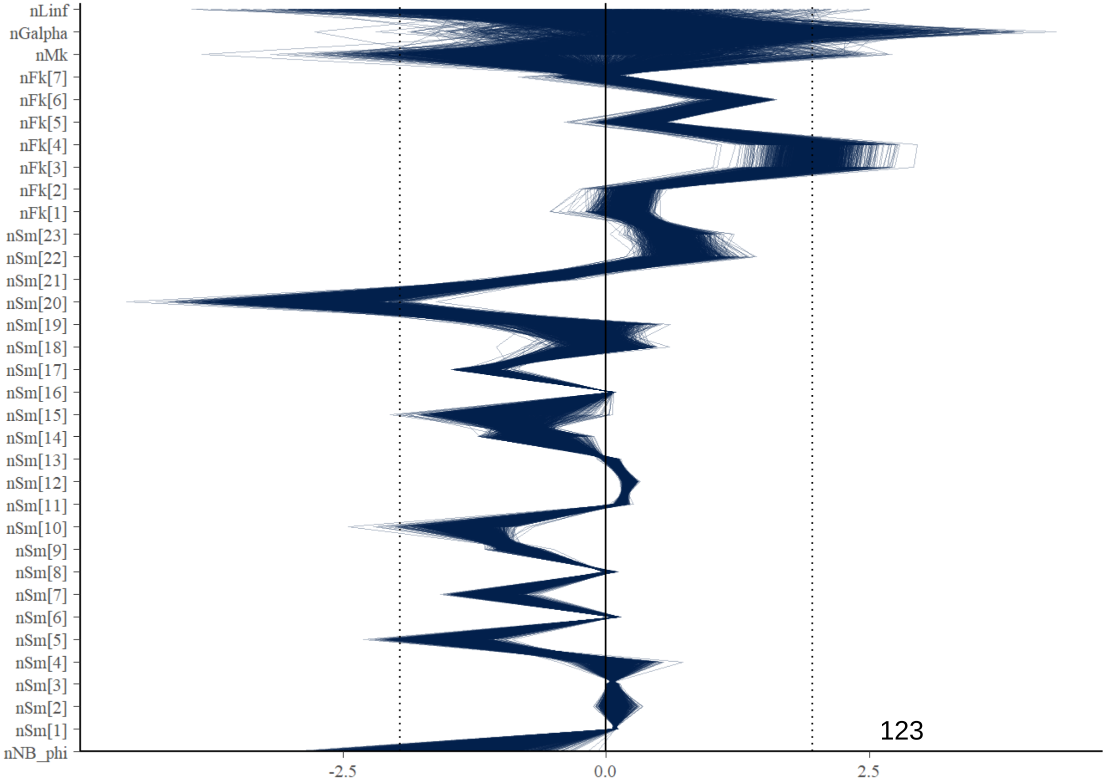
Probability Density
6
4
2
0
0.00
0.25
0.50
0.75
1.00
Spawning Potential Ratio



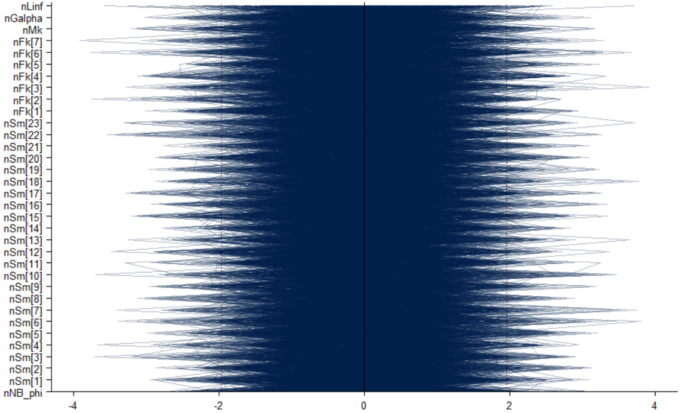
Selectivity
1.5
1.0
0.5
0.0
50
100
150
200
Length
Gear
BB
GI
HD
LL
OT
PS-FS
PS-LS

Parameter Estimates

Posterior



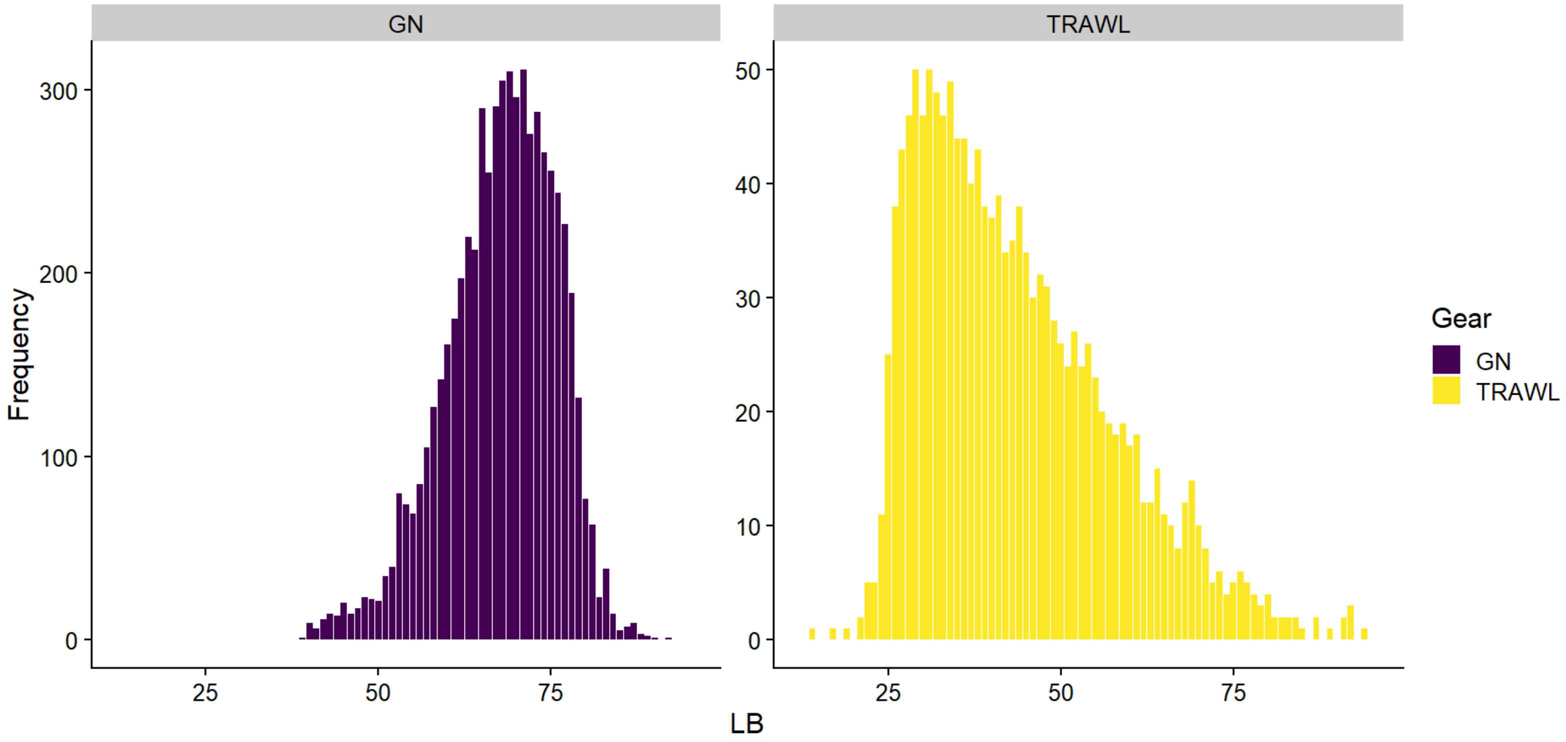
Prior



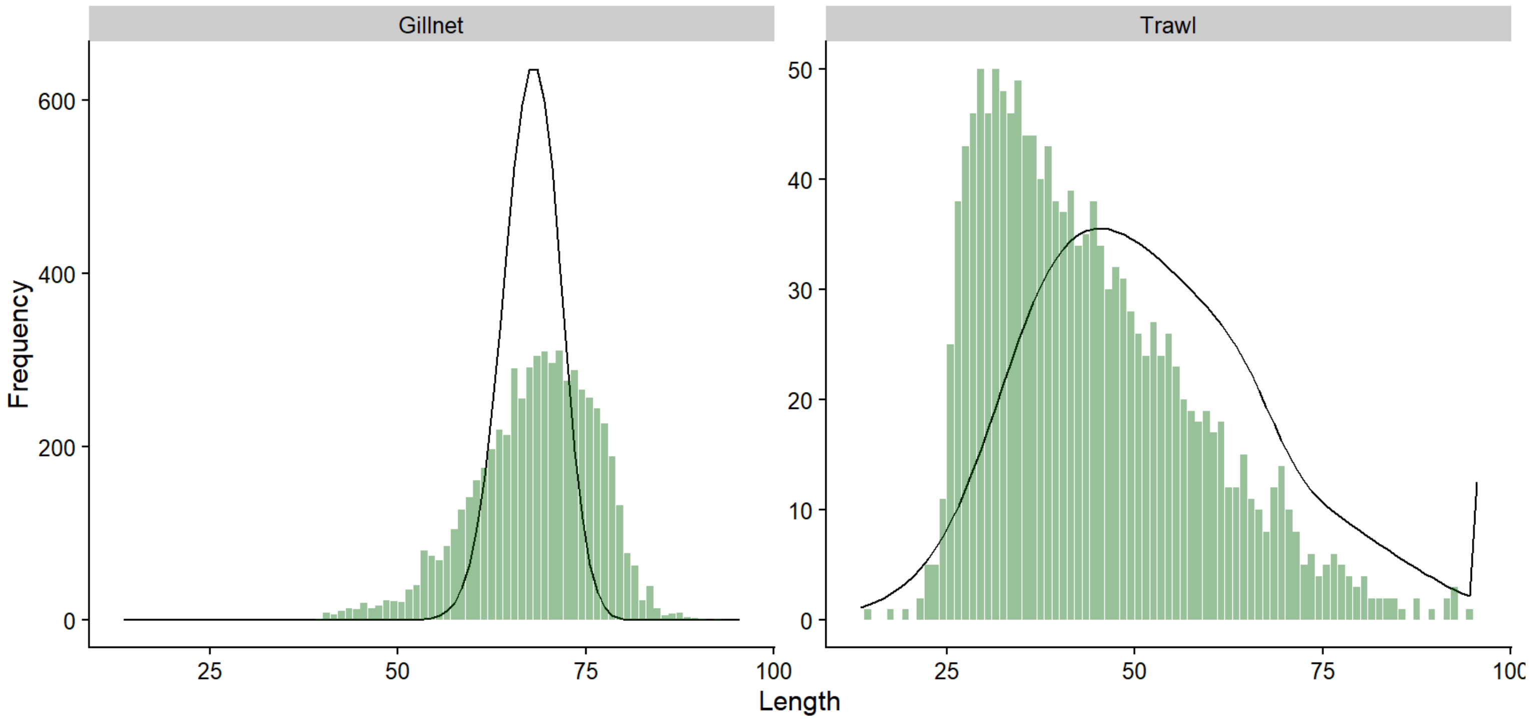
Conclusion

- Bayesian length-based catch curve with flexible modelling of mortality-at-length implemented in the *fishblicc* package
- *Key assumption* is population is in stationary state
- *Fits* single and multiple sample length frequency data
- *Estimates* F-at-length, selectivity, SPR, YPR etc.
- *Used* for data limited assessments + examine selectivity models
- *Caution* with overfitting (use sensitivities)

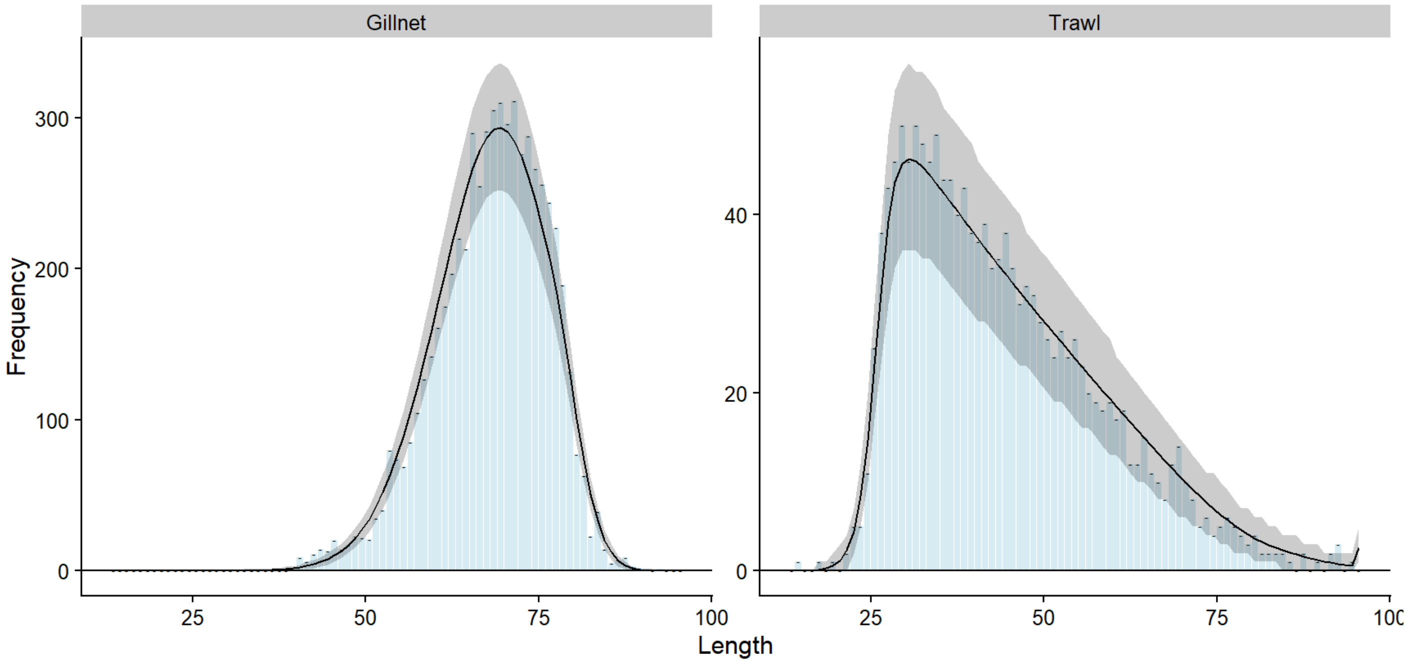
APPENDIX 8: SAMPLE FISHBLICC ASSESSMENT OUTPUT



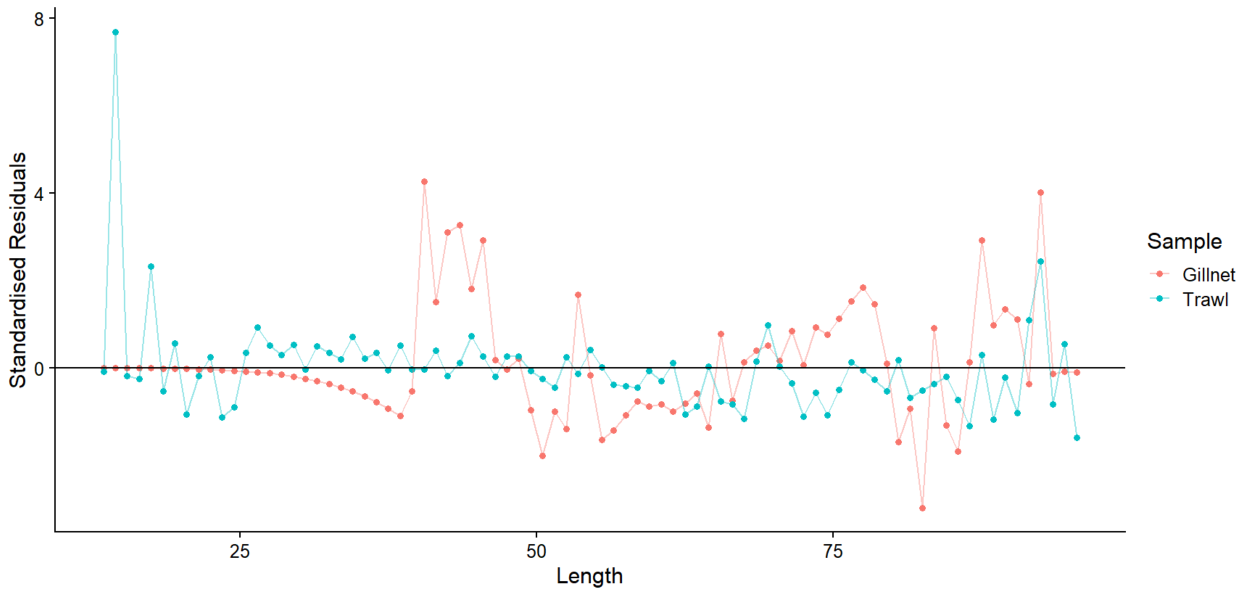
"Length frequency data 2000-03 for Guyana seatrout (*Cynoscion virescens*) broken down by main gear type."



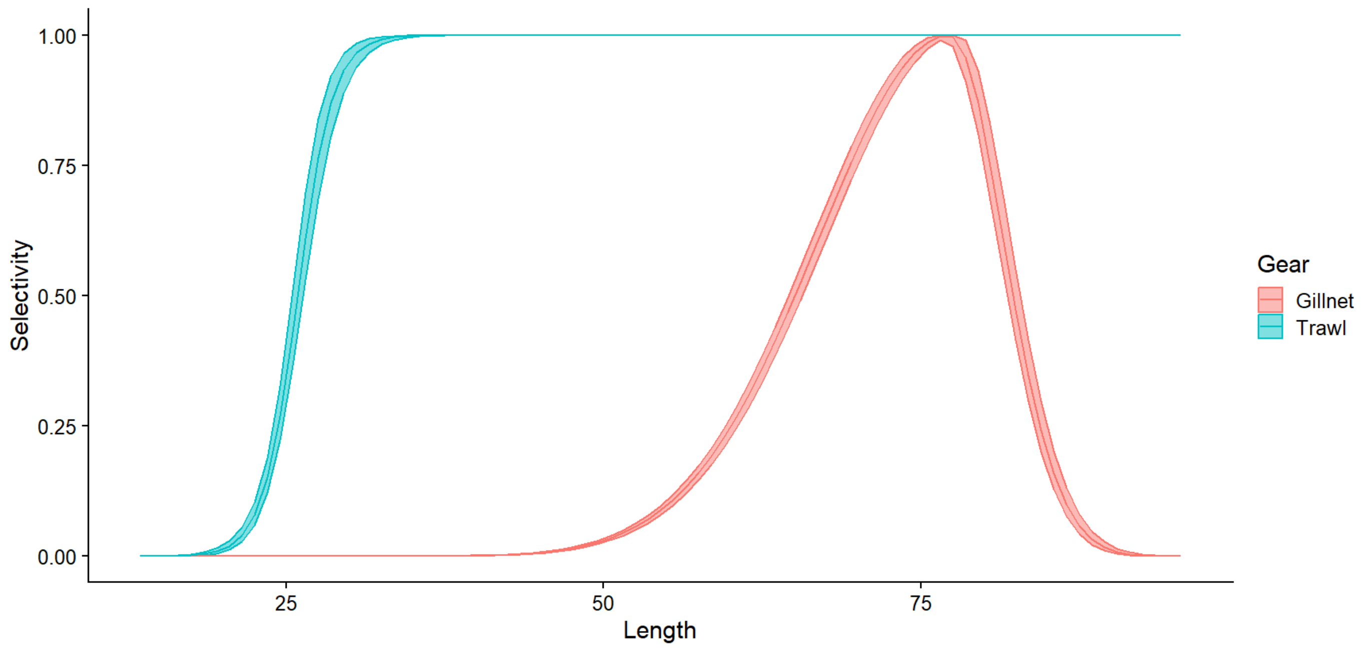
"Expected length frequency based on the prior parameter means (line) plotted over the observed frequency (histogram). If necessary these can be adjusted using the `blip_sel` function."



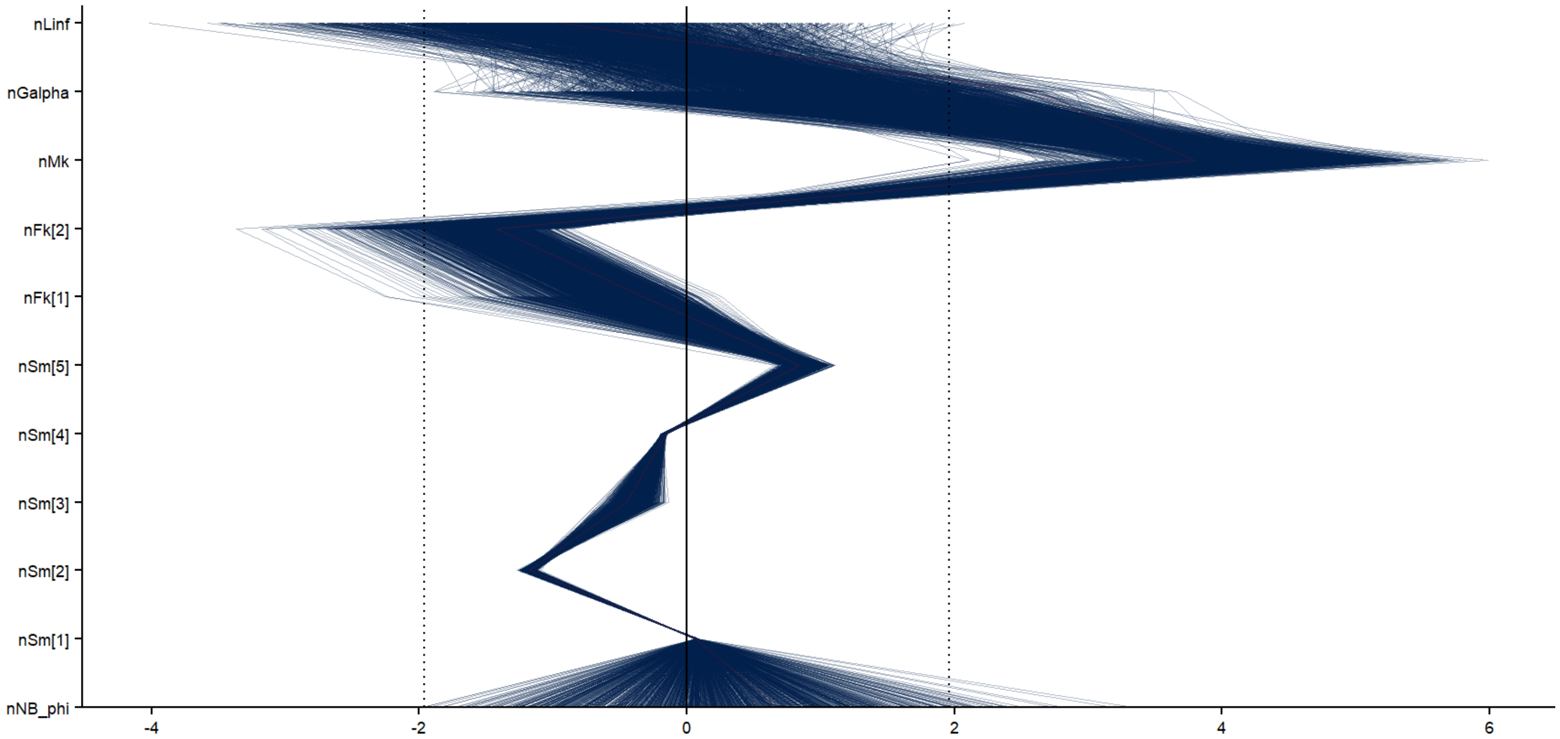
"Observed and expected frequency for the maximum posterior density fit with mixed selectivity, constant natural mortality and logistic trawl selectivity." plot_posterior(res)

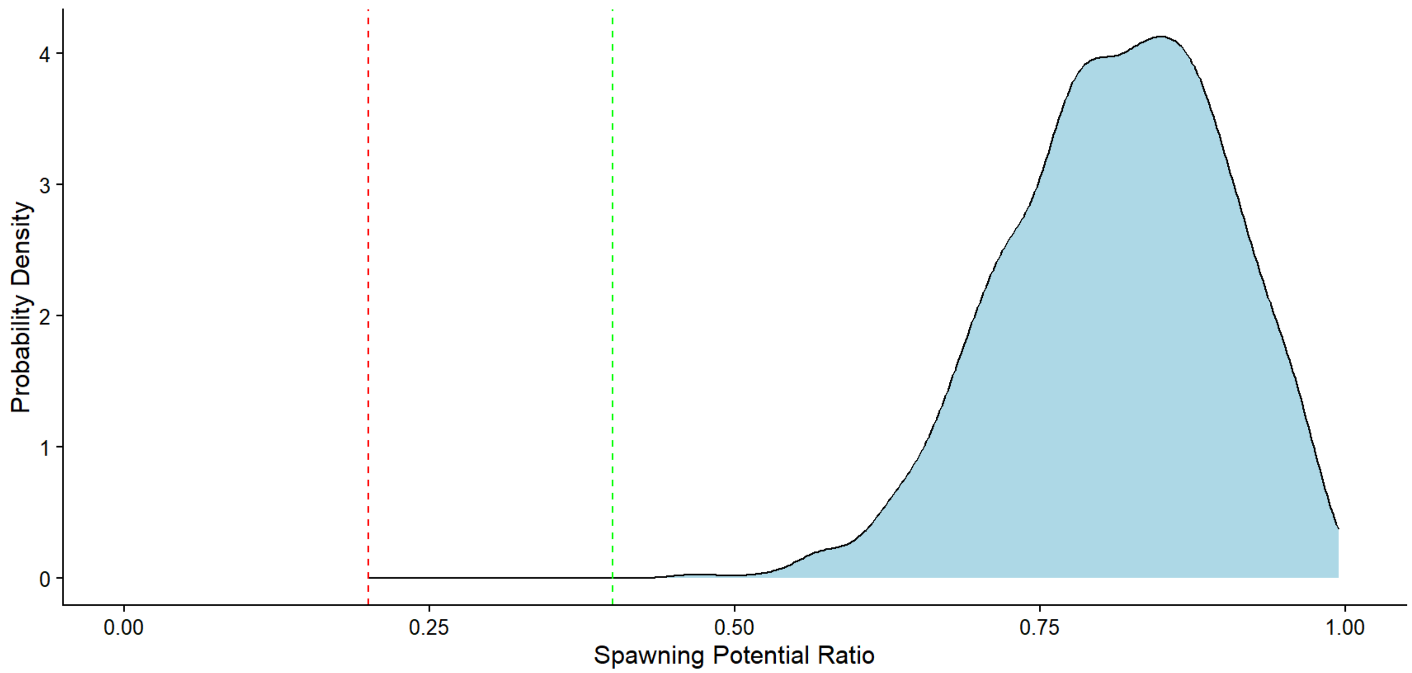


"Standardised residuals for the logistic selectivity mixture model."



Selectivity
1.00
0.75
0.50
0.25
0.00
25
50
75
Length
Gear
Gillnet
Trawl


nLinf
nGalpha
nMk
nFk[2]
nFk[1]
nSm[5]
nSm[4]
nSm[3]
nSm[2]
nSm[1]
nNB_phi
-4
-2
0
2
4
6



Probability Density
4
3
2
1
0
0.00
0.25
0.50
0.75
1.00
Spawning Potential Ratio

Parameter	Value
Linf	94.242
Galpha	121.153
Mk	2.407
Fk[1]	0.553
Fk[2]	0.015
Sm[1]	77.272
Sm[2]	0.005
Sm[3]	0.027
Sm[4]	25.865
Sm[5]	0.731
NB_phi	112.456

Parameter	Mean	SD	N (eff)	Rhat
Linf	94.206	0.942	1,736	0.999
Galpha	123.739	27.293	2,026	0.999
Mk	2.413	0.123	880	1.003
Fk[1]	0.533	0.293	655	1.005
Fk[2]	0.015	0.008	678	1.004
Sm[1]	77.236	0.567	572	1.010
Sm[2]	0.005	0.000	807	1.009
Sm[3]	0.027	0.003	706	1.012
Sm[4]	25.880	0.335	1,219	1.001
Sm[5]	0.731	0.079	1,249	1.000
NB_phi	117.237	47.617	1,289	1.002

LB-SPR stock assessment method

TOMAS WILLEMS, PHD

The LB-SPR method

LB-SPR = **L**ength-**B**ased estimation of **S**pawning **P**otential **R**atio

A new method for data-poor fisheries

ICES Journal of Marine Science Advance Access published February 9, 2014

ICES Journal of Marine Science

ICES International Council for the Exploration of the Sea
CIEM Conseil International pour l'Exploration de la Mer

ICES Journal of Marine Science; doi:10.1093/icesjms/fsu004

A novel length-based empirical estimation method of spawning potential ratio (SPR), and tests of its performance, for small-scale, data-poor fisheries

Adrian Hordyk[1*], Kotaro Ono[2], Sarah Valencia[3], Neil Loneragan[1], and Jeremy Prince[1,4]

[1]Centre for Fish, Fisheries and Aquatic Ecosystems Research, Murdoch University, 90 South Street, Murdoch, WA 6150, Australia
[2]School of Aquatic and Fisheries Science, University of Washington, Seattle, WA, USA
[3]Bren School of Environmental Science and Management, University of California, Santa Barbara, CA, USA

The LB-SPR method

- SPR **compares** the spawning ability (or reproductive capacity) of a **stock in the fished condition** to the stock's spawning ability in the **unfished condition**

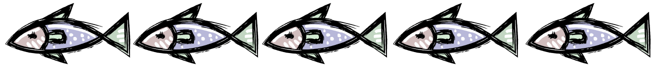
- First published in 2014

- Now widely applied to data-limited fisheries and recommended by FAO

Spawning potential ratio

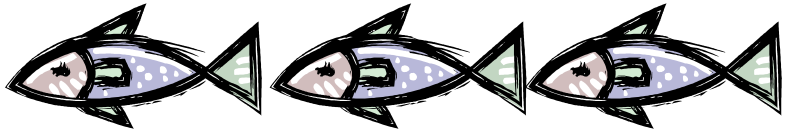
No Fishing

Age 1



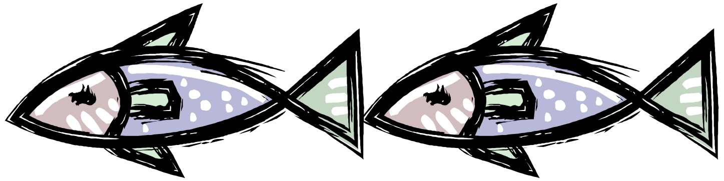
5 x 0 eggs

Age 2



3 x 100 eggs

Age 3



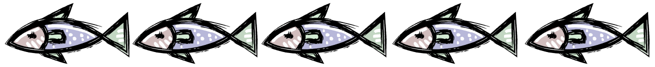
2 x 200 eggs

700 eggs

Spawning potential ratio

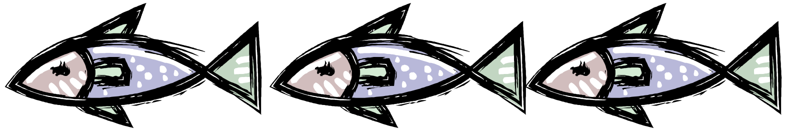
No Fishing

Age 1



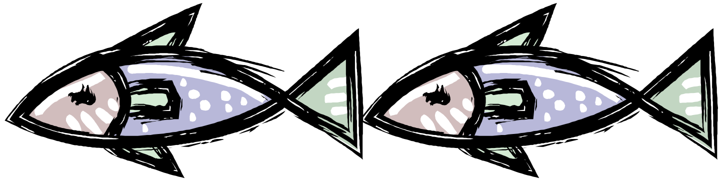
5 x 0 eggs

Age 2



3 x 100 eggs

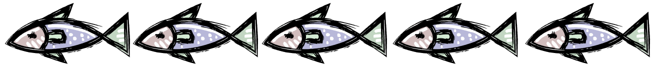
Age 3



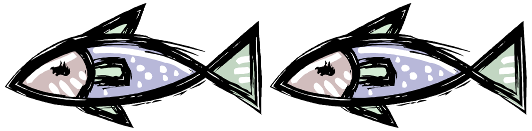
2 x 200 eggs

700 eggs

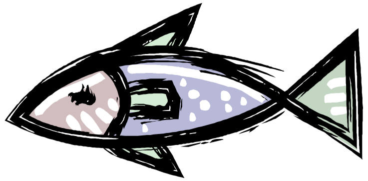
Fishing



5 x 0 eggs



2 x 100 eggs

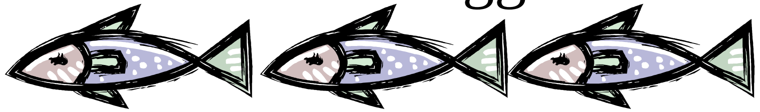
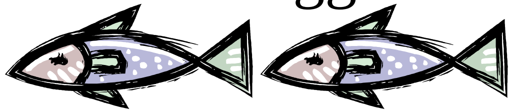
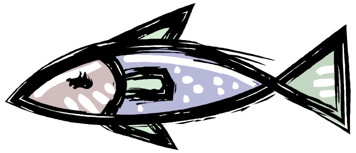


1 x 200 eggs

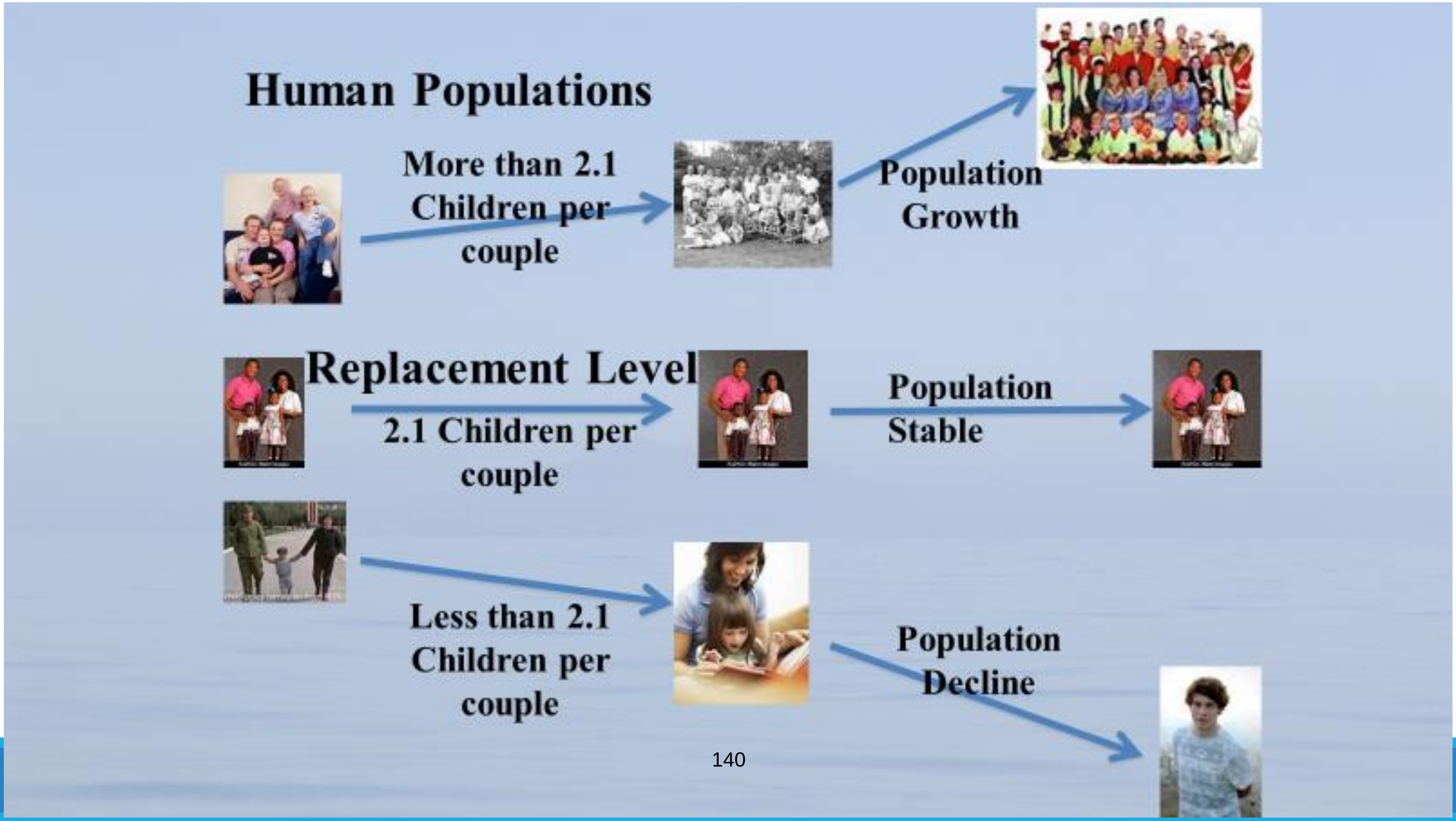
400 eggs

Spawning potential ratio

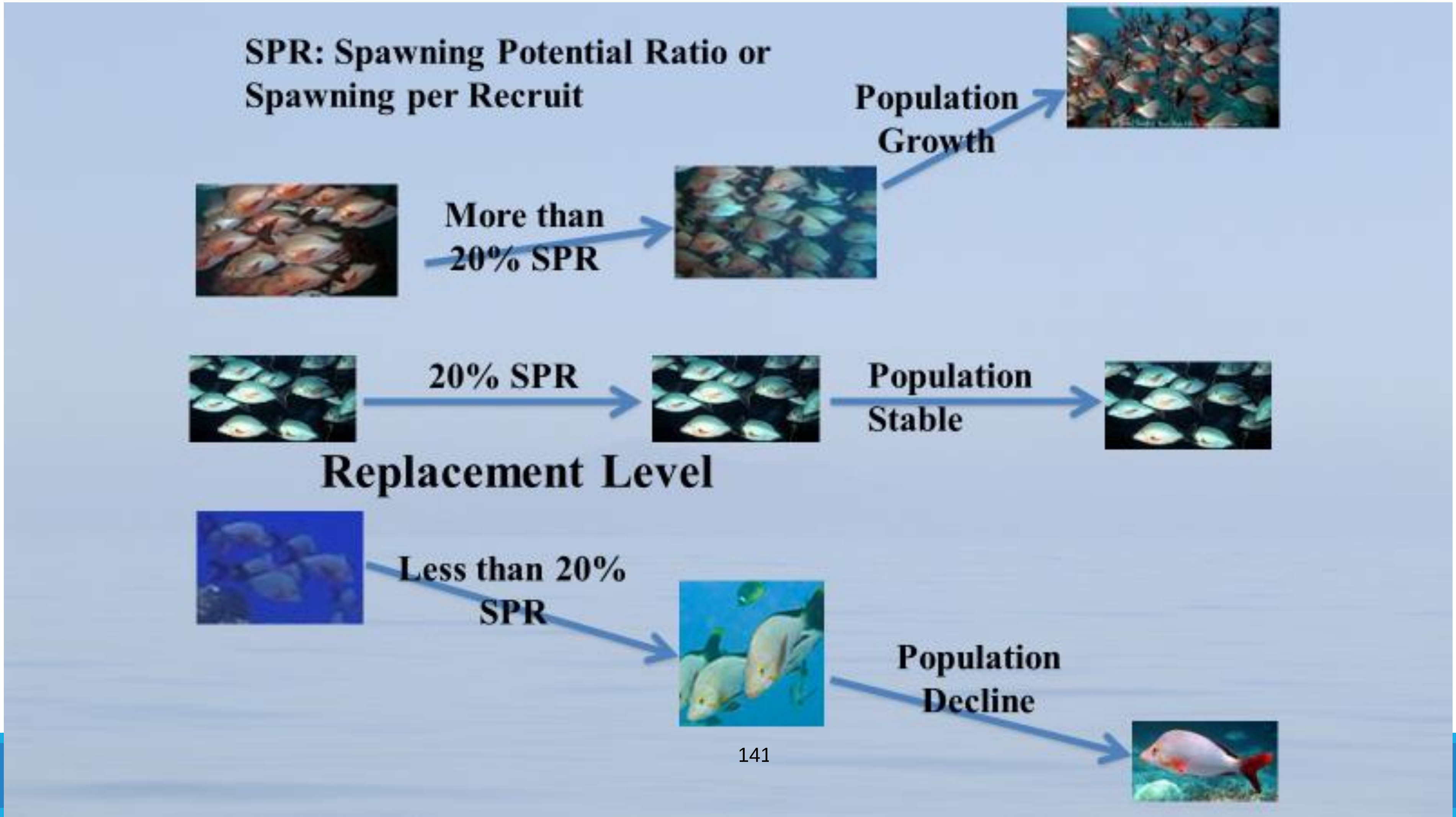
SPR = 400/700 = 0.57 or 57%

	No Fishing	**Fishing**
Age 1	 5 x 0 eggs	 5 x 0 eggs
Age 2	 3 x 100 eggs	 2 x 100 eggs
Age 3	 2 x 200 eggs	 1 x 200 eggs
	700 eggs	**400 eggs**

Spawning potential ratio



Spawning potential ratio



Spawning potential ratio

Internationally accepted SPR values corresponding to Reference Points used by conventional stock assessment methods

Reference Points	SPR Values
Limit Reference Point	20%
Lower (Target) MSY	30%
Upper (Target) MSY	40%
Precautionary MSY / MEY	50%
Precautionary / Rebuild SPR	*60%*

The LB-SPR method

SPR is a useful and relevant **indicator** to assess stock health

Scores of SPR are compared with **reference points**

SPR = 100% → unfished stock

SPR = 0% → no spawning (all female/mature fish removed)

- **SPR = 40%** is considered safe for many species

- Use SPR to define fishing effort

$F_{40\%SPR} \sim F_{MSY}$

When $F > F_{40\%SPR}$ → overfishing

The LB-SPR method

- Collection of *in-situ* data on **length-distribution** and **maturity** of selected species
- Biological parameters are ‘borrowed’ from **literature**

Length-frequency distributions

Size-of-Maturity

Life-History Ratio’s

SPR Estimates

Fisheries Data Collection and Challenges in Guyana

An Overview of Methods, Data Sources, and Key Issues

Ministry Of Agriculture, Fisheries Department

Introduction to Fisheries Data Collection

- Fisheries data collection is crucial for ensuring the sustainable management of fish stocks and ecosystems.
- **Purpose:** To monitor fish populations, assess ecosystems, and ensure sustainable practices.
- **Types of Fisheries:**
  - **Marine Fisheries**
  - Freshwater/Inland Fisheries
  - Aquaculture

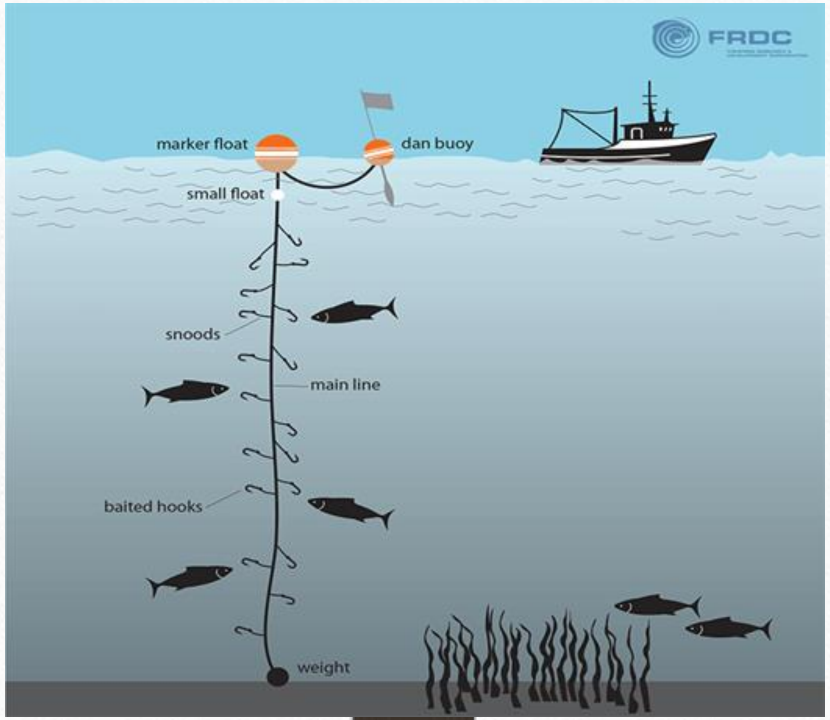
Marine Fishery Sector

- Industrial fisheries

- Trawls (Seabob trawls & Prawns trawls)

Semi-industrial fisheries

- Traps vessels
- Hand lines Vessels



Artisanal Fishery

- Out board / inboard wooden vessels e.g.

- Inboard (GNPin)
- Cabin cruiser (GNPcc)
- Bangamary vessels (GNN)
- Anchor Seine
- Caddel
- Chinese vessel

Why Fisheries Data Collection is Crucial

- **Sustainable Management:** Prevents overfishing and protects fish stocks.
- **Biodiversity Conservation:** Ensures the protection of aquatic life.
- **Policy Making:** Guides the creation of effective regulations.
- **Tracking Fish Populations:** Helps scientists understand species health and behavior.
- **Economic Decision Making:** Informs markets and industries dependent on fisheries.

Data Collected

- Catch Data
- Effort Data
- Biological Data

Data Management And Storage

- Calipseo by FAO (2025 – present)

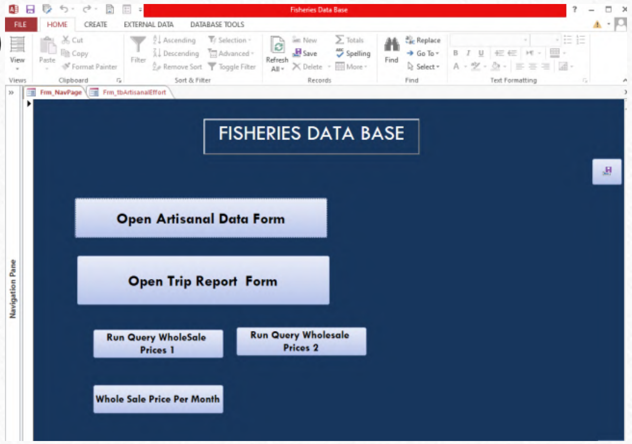
 - Complete form info stored

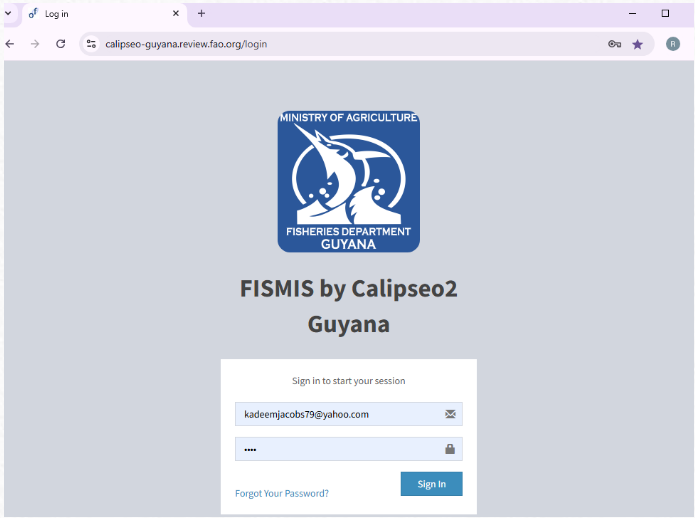
- Microsoft Access (2021-2024)

 - Complete form info stored

- Microsoft Excel (-2020)

 - only catch by species





Challenges in Fisheries Data Collection

- Lack of cooperation during data collection activities in the Artisanal Sector
- Access and Logistics: Artisanal fishing communities in Guyana are often dispersed across remote coastal regions, posing logistical challenges in reaching and surveying these communities.
- Seasonal Variability: Artisanal fishing activities can vary significantly with seasons and weather conditions. Timing the survey to capture representative data across different seasons added complexity to the process.
- Data Quality and Validity: Ensuring the quality and validity of data collected from artisanal fishers, Respondents presented varying levels of literacy and familiarity with survey processes, is essential.
- Fishfolks not trusting the Fisheries Department

Thank You

Suriname fishblicc Assessment

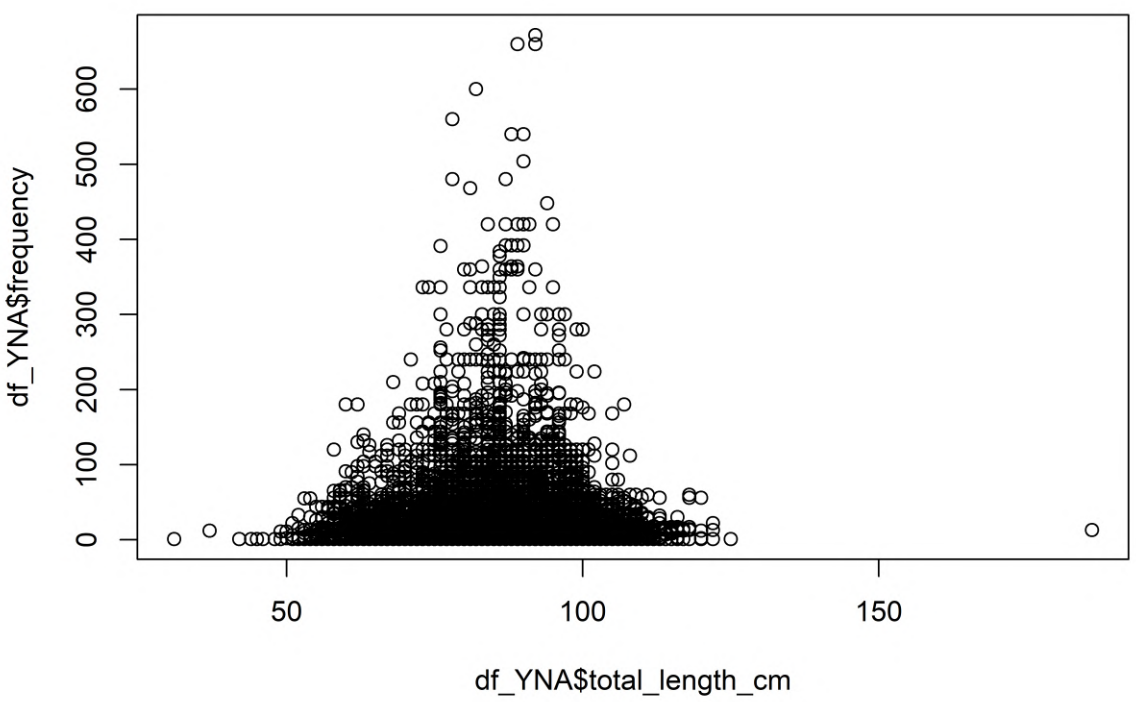
Bang Bang Stock

AUTHOR
Mishel Rañada & Nandini Kalpoe

PUBLISHED
April 3, 2025

Abstract
The article reports a stock assessment of Bang Bang (*Cynoscion acoupa*) using a length-based catch curve method (fishblicc).

Table of contents




```
# A tibble: 6 × 3
  length frequency length_bin
   <dbl>     <dbl>      <dbl>
1     31         1         30
2     37        12         35
3     42         1         40
4     44         1         40
5     45         2         45
6     46         1         45
```

1 Introduction

The acoupa weakfish, *Cynoscion acoupa* (Lacèpede, 1801), is found across the Brazilian coast. It has been observed from Argentina all the way to the Panama Canal and lives in the demersal layer in shallow estuary brackish waters. Its highly valued meat makes it a commercially significant species, and its swimbladder, which is also used to make glue, beverage emulsifier, and fining agent, fetches high prices. The acoupa weakfish is a major fishing resource with great socioeconomic importance.

Data were collected 2022-2025 from length sampling of landings.

Bang Bang is predominantly caught in driftnet.

2 Life History Parameters

The recorded maximum length of *C. acoupa* was 125cm.

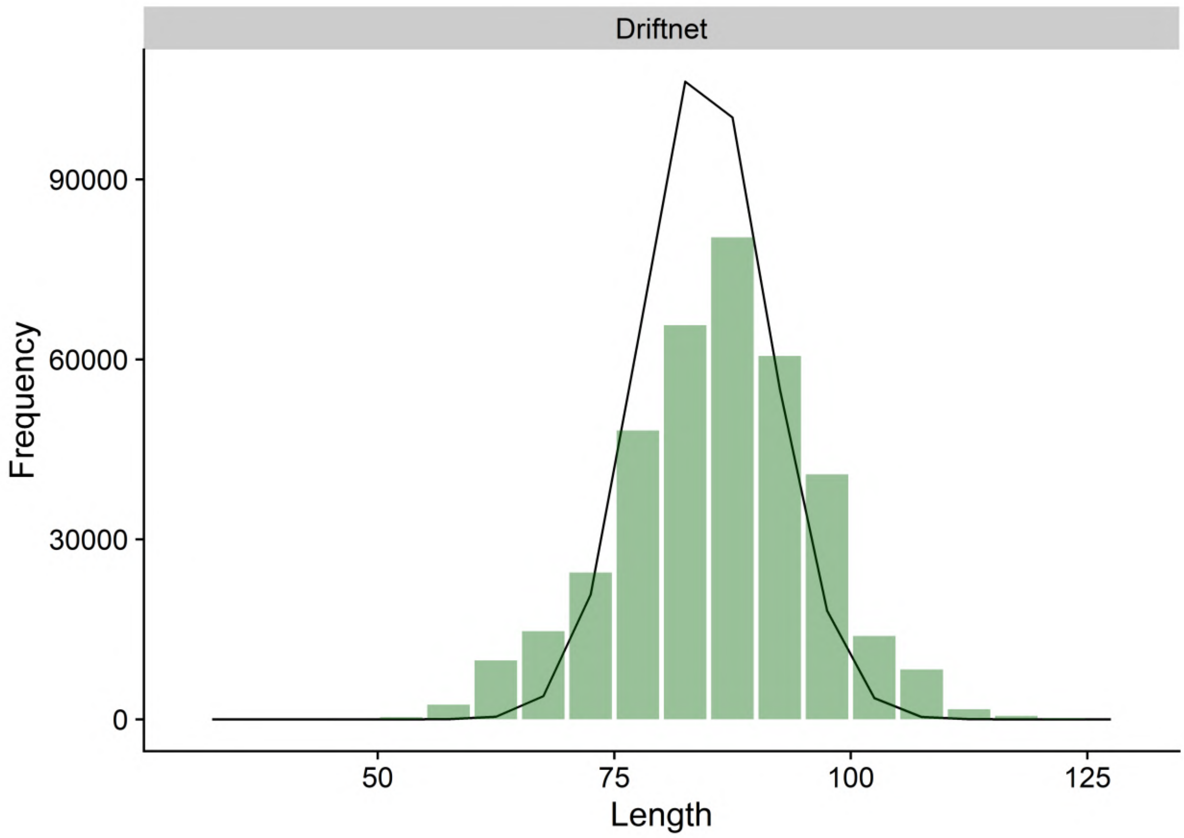
The growth parameters used in the stock assessment attempt were K = 0.270, $L\infty$= 128.9, and M/K of around 0.74.

The length at maturity information: L50 = 49, and L95 = 59.

3 Base Model

It might be expected that driftnet selectivity would follow a normal distribution but we used double sided distribution with some refinement to have a better fit.

Figure 1: Expected length frequency based on the prior parameter means (line) plotted over the observed frequency (histogram).



The parameter estimates are reasonable and estimated SPR is relatively high.

Figure 2: Observed and expected frequency for the maximum posterior density fit with mixed selectivity, constant natural mortality and logistic trawl selectivity.

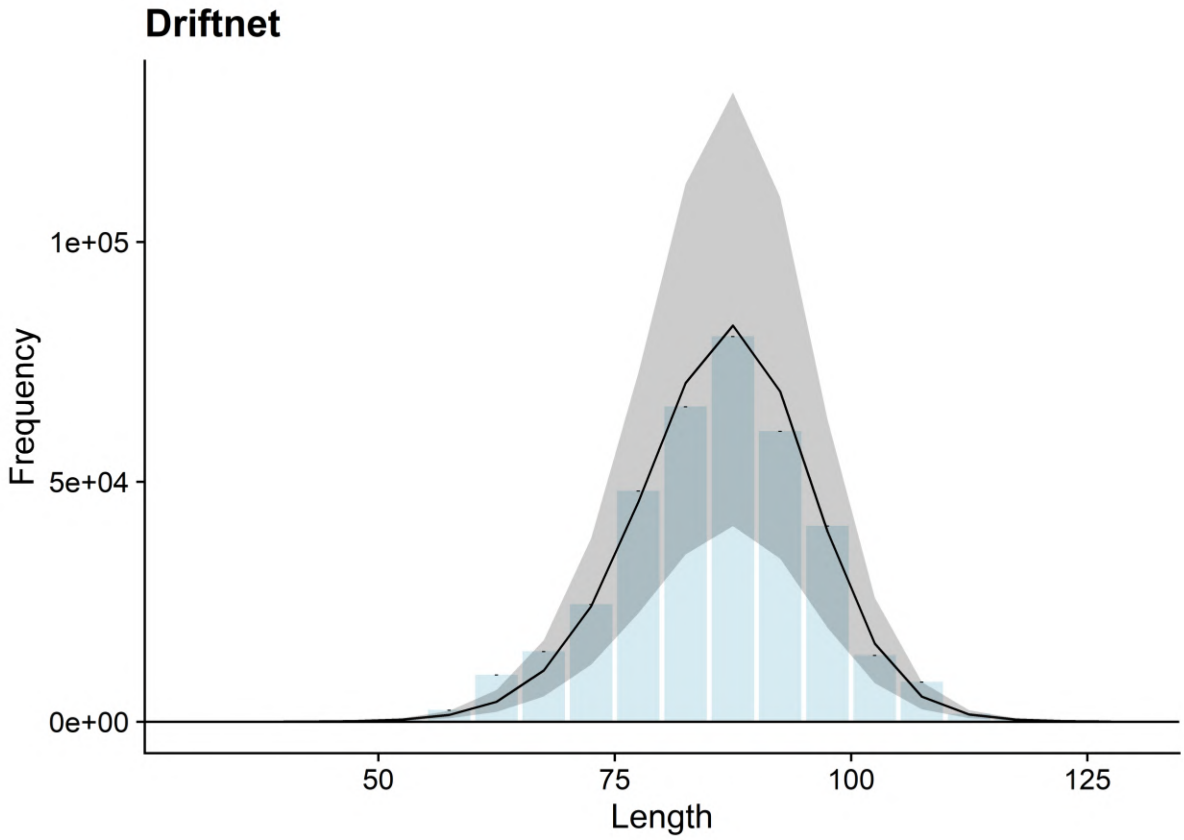
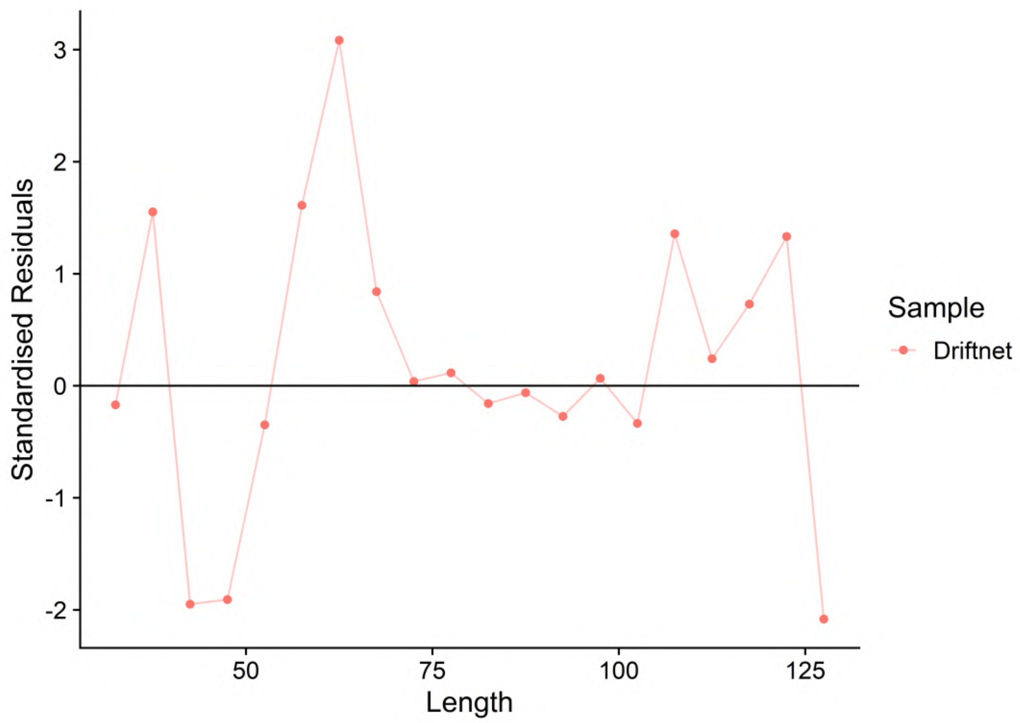


Table 1: Model parameter estimates based on maximum posterior density fit.

Parameter	Value
Linf	128.862
Galpha	115.400
Mk	0.746
Fk[1]	7.673
Sm[1]	105.878
Sm[2]	0.002
Sm[3]	0.001
NB_phi	5.175
Gbeta	0.896
lp__	-192.728
SPR[1]	0.147
B_B0[1]	0.053
YPR[1]	3,379.242

The standardised residual plot can be used to identify outliers (Figure 3). Outliers are particularly important when using normal selectivity functions which predict very low probabilities of capture in their tails.

Figure 3: Standardised residuals for the logistic selectivity mixture model.



4 MCMC Fit

The base model was fitted using Stan MCMC algorithm (mc-stan.org). The MCMC converged (Table 2) and the model fitted the data well (Figure 4).

Figure 4: Expected length frequency based on the MCMC posterior parameters (line) for the base model plotted over the observed frequency (histogram).

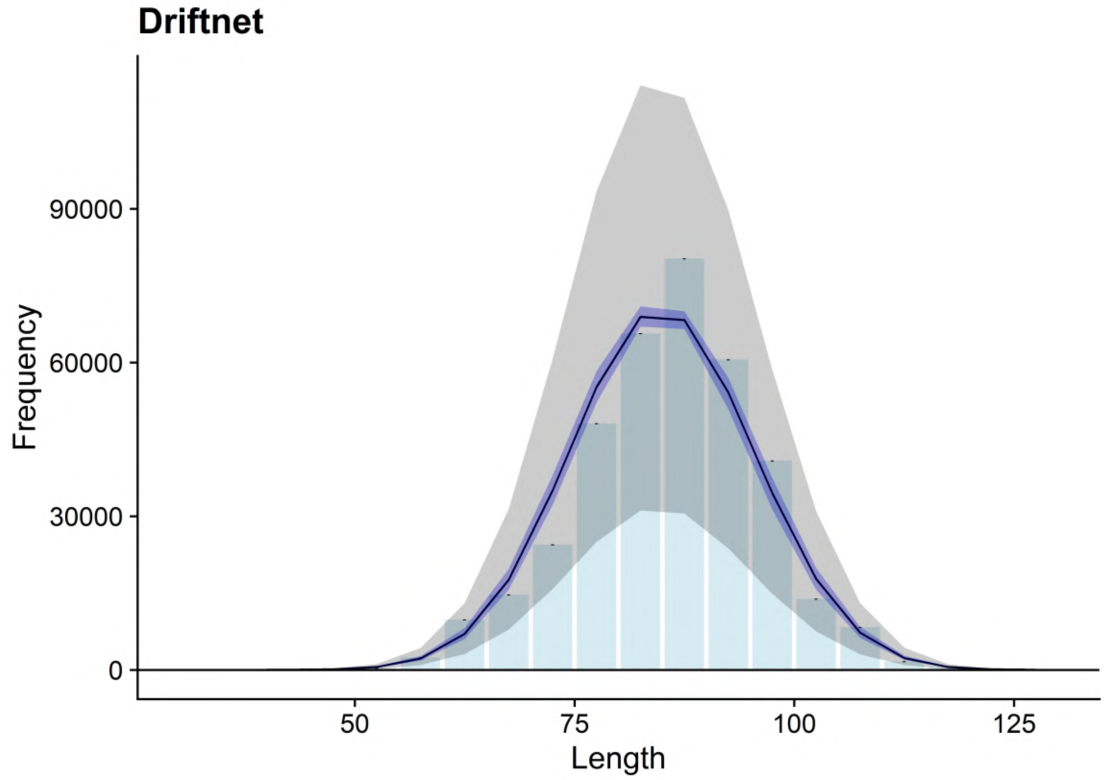


Table 2: MCMC parameter estimates with the effective sample size and MCMC convergence statistic (Rhat). Effective sample size needs to be 500 or more for reliable estimates. A Rhat value close to one indicates convergence.

Parameter	Mean	SD	N (eff)	Rhat
Linf	128.642	1.006	1,652	0.999
Galpha	117.264	30.487	1,441	0.999
Mk	0.757	0.074	1,637	1.001
Fk[1]	0.264	0.304	904	1.006
Sm[1]	84.842	0.679	1,113	1.005
Sm[2]	0.005	0.000	1,122	1.006
NB_phi	6.611	2.010	1,268	1.003
Gbeta	0.912	0.237	1,442	0.999
SPR[1]	0.881	0.119	977	1.005
lp__	-187.817	1.977	739	1.002

Figure 5: MCMC parameter plots indicating relative support for each parameter from the data. The parameters are drawn from standard normals (mean=0, sd=1). If no data were present, 95% of the lines would be spread in a normal density pattern within the vertical dotted lines, so departures from this indicate estimation support from the data.

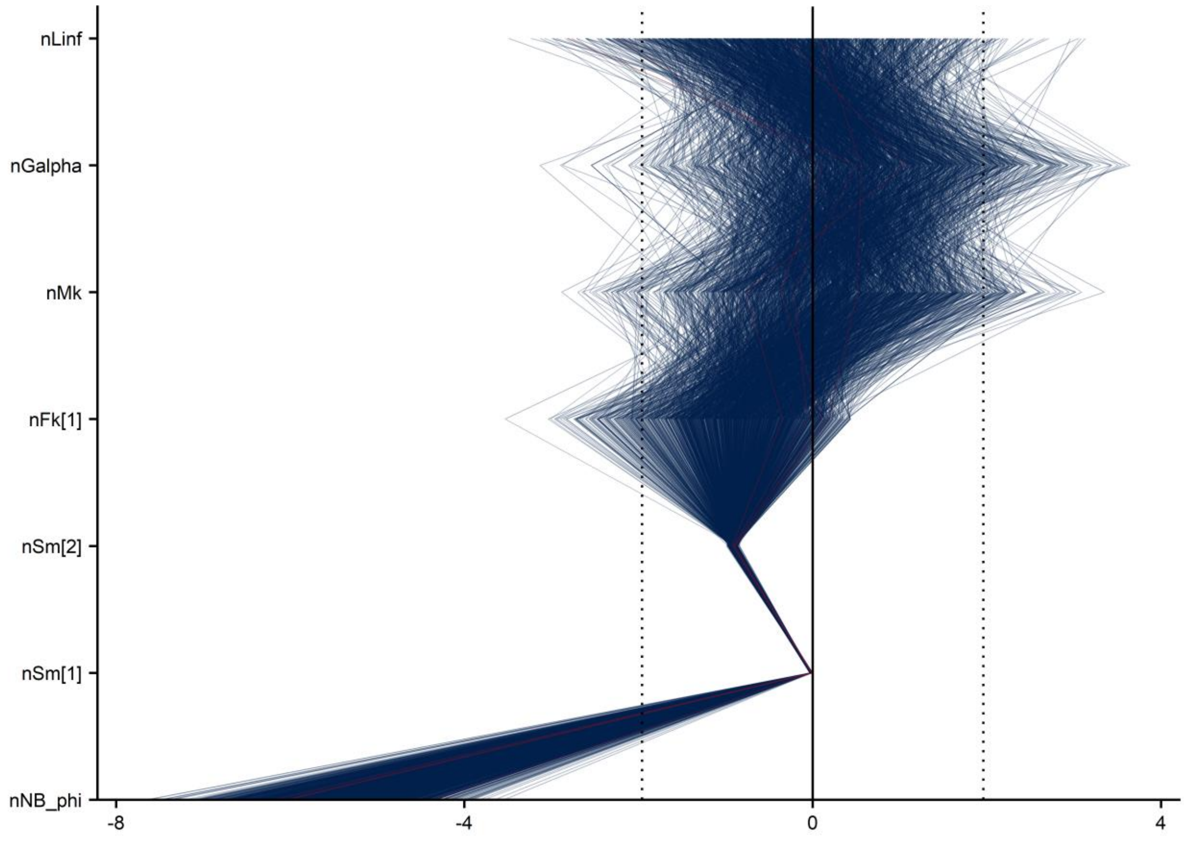


Figure 6: Spawner potential ratio probability density posterior estimated from the MCMC.

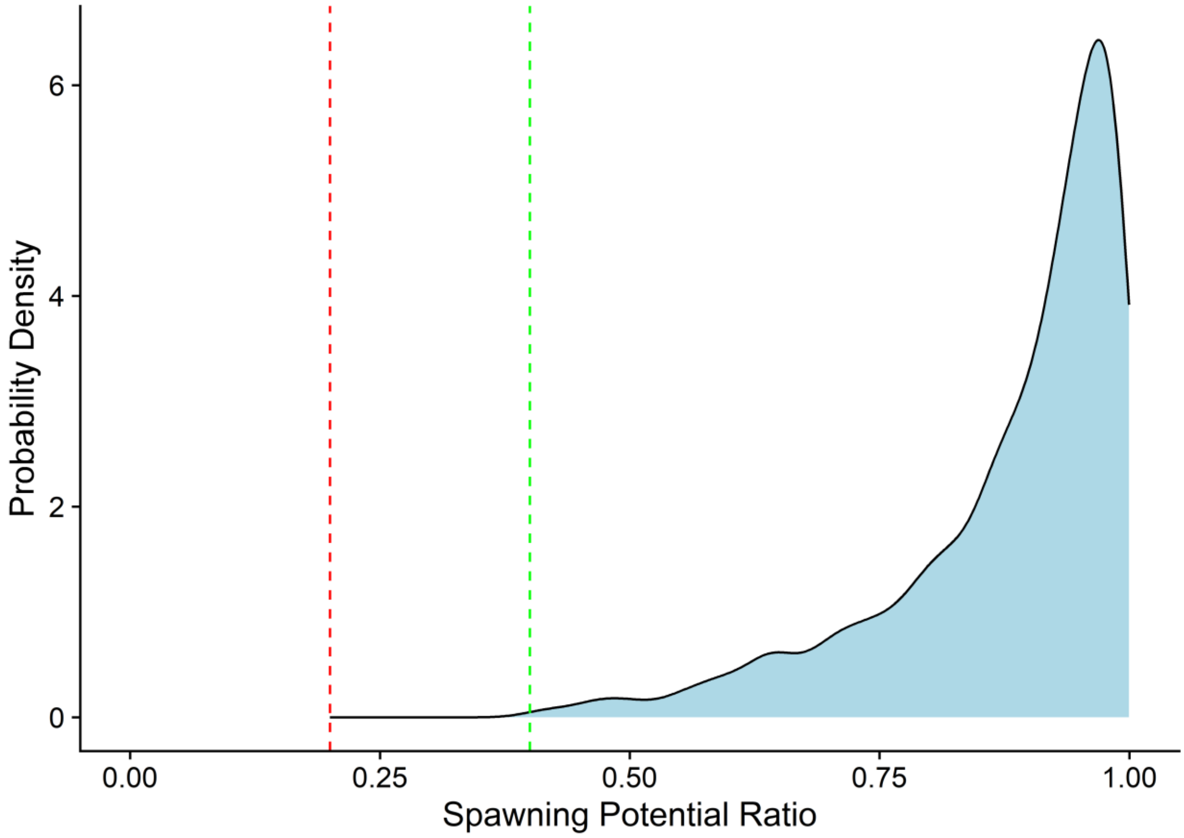
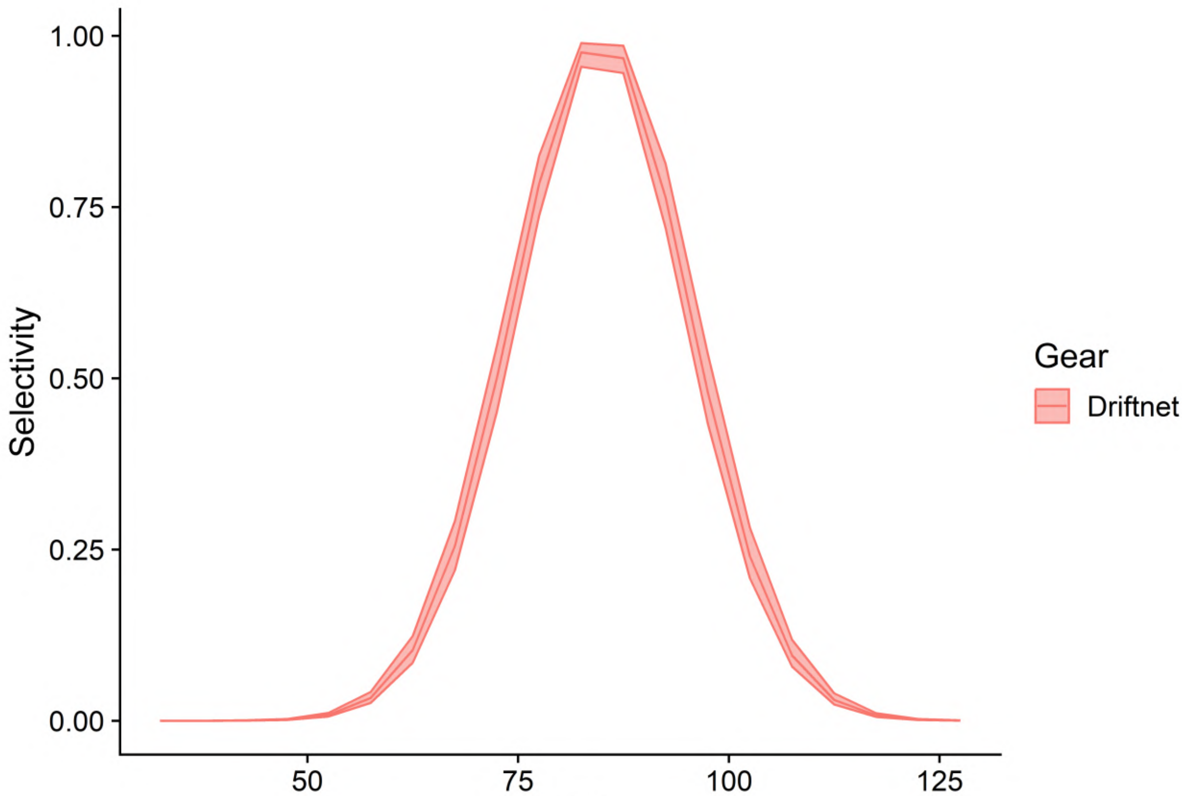


Figure 7: Estimated selectivity for driftnet gear.



5 Discussion

Discussion or conclusion of results.

6 References

Suriname Barracuda

AUTHOR
S. Kharpatoe and G. Poeran

PUBLISHED
April 3, 2025

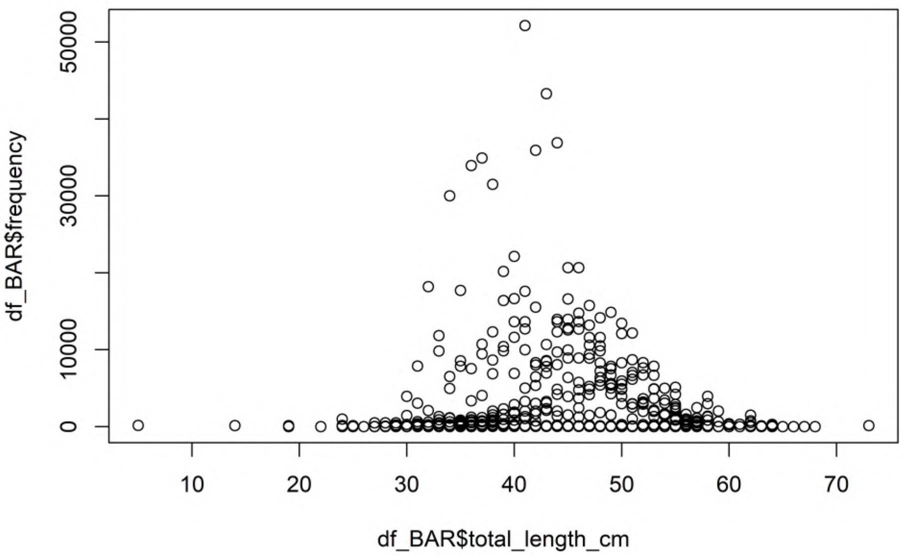
BARRACUDA
This document describes the species type Barracuda (*Sphyraena guachancho*) that is found in the western Atlantic Ocean. It is a predatory marine fish belonging to the family Sphyraenidae. This species typically inhabits coastal waters, often near sandy or muddy bottoms, and is commonly caught in bottom trawl fisheries.

Body Shape: Long, slender, and torpedo-shaped.
Size: Maximum recorded length 200 cm, but more commonly 50–100 cm.

In Suriname case we calculated the L_by ;Lmax * 1.05 (68 * 1.05= 71.4). The maximum length was found in our dataset from the bottomtrawl.

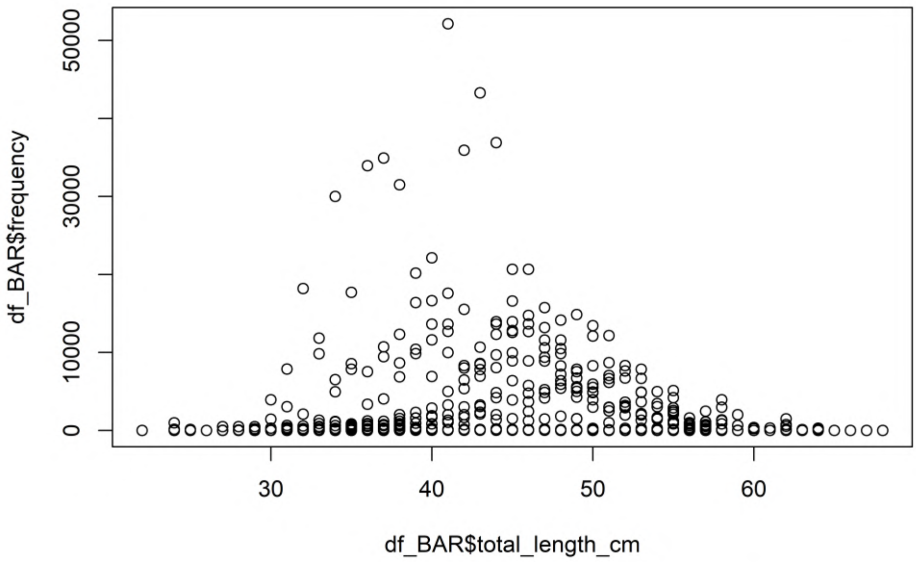
Data collection for the Barracuda (Bottomtrawl)
The length data for Suriname is being collected by the data observers at the industrial landing sites designated by us.

Assessment results for Barracuda (Bottomtrawl)
First, we plot the raw data



The values below 20 and over 70 are probably outliers.

New plot without outliers.

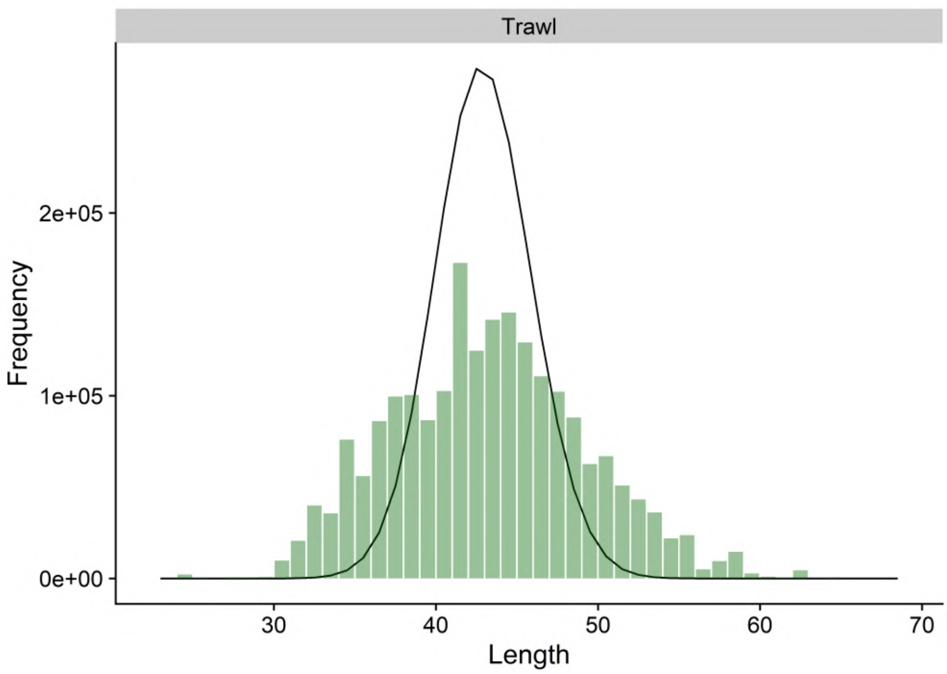


Rename Columns and Summarize the Frequency

Calculate Linf based on Lmax

Bayesian Model

Expected length frequency based on the prior parameter means (line) plotted over the observed frequency (histogram). If necessary, these can be adjusted using the blip_sel function."



```
Chain 1: Initial log joint probability = -324342
Chain 1:     Iter      log prob        ||dx||      ||grad||       alpha      alpha0  # evals  Notes
Chain 1:        1       -324342             0   4.16274e+06      0.001       0.001       12
Chain 1: Exception: neg_binomial_2_lpmf: Location parameter[1] is nan, but must be positive finite! (in 'string', line 291, column 8 to column 61)
Exception: neg_binomial_2_lpmf: Location parameter[1] is nan, but must be positive finite! (in 'string', line 291, column 8 to column 61)
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Exception: neg_binomial_2_lpmf: Location parameter[1] is nan, but must be positive finite! (in 'string', line 291, column 8 to column 61)
```
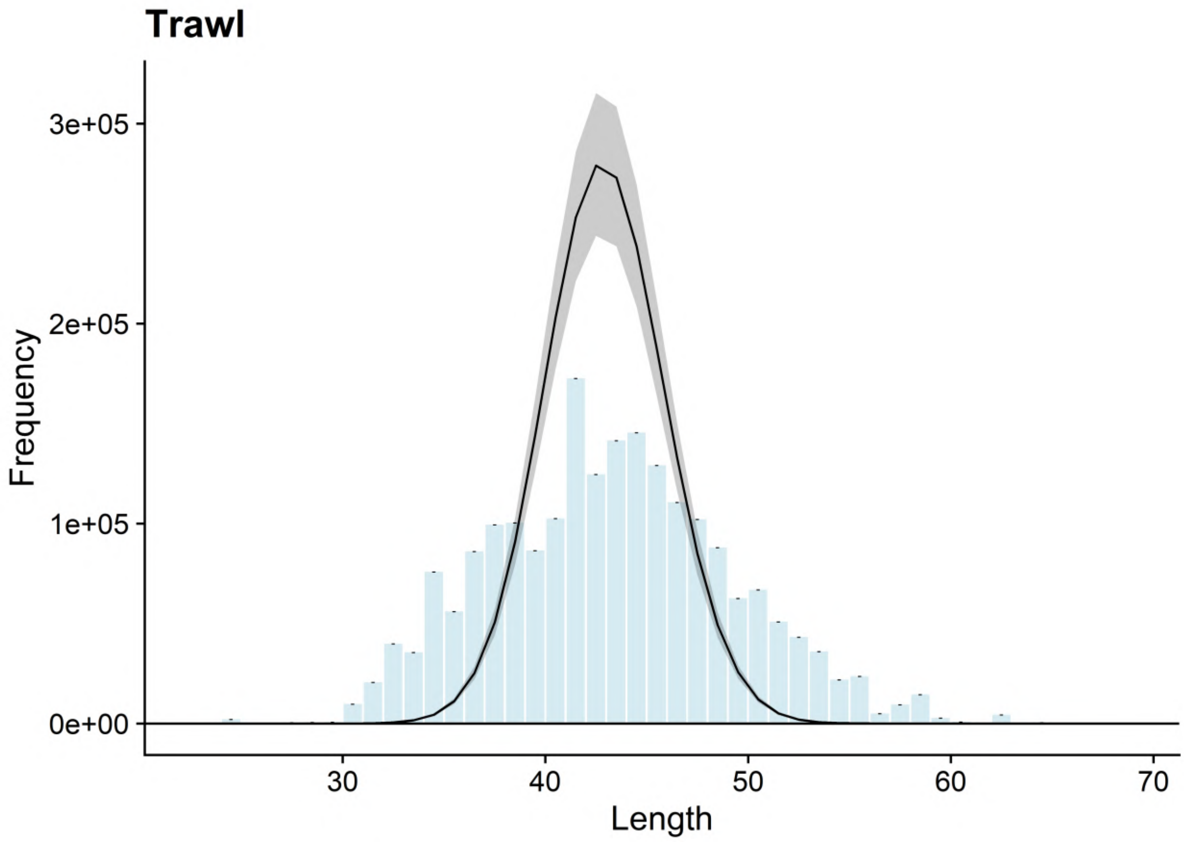

Chain 1: Optimization terminated with error:
Chain 1:   Line search failed to achieve a sufficient decrease, no more progress can be made
Error in chol.default(-H) : the leading minor of order 3 is not positive

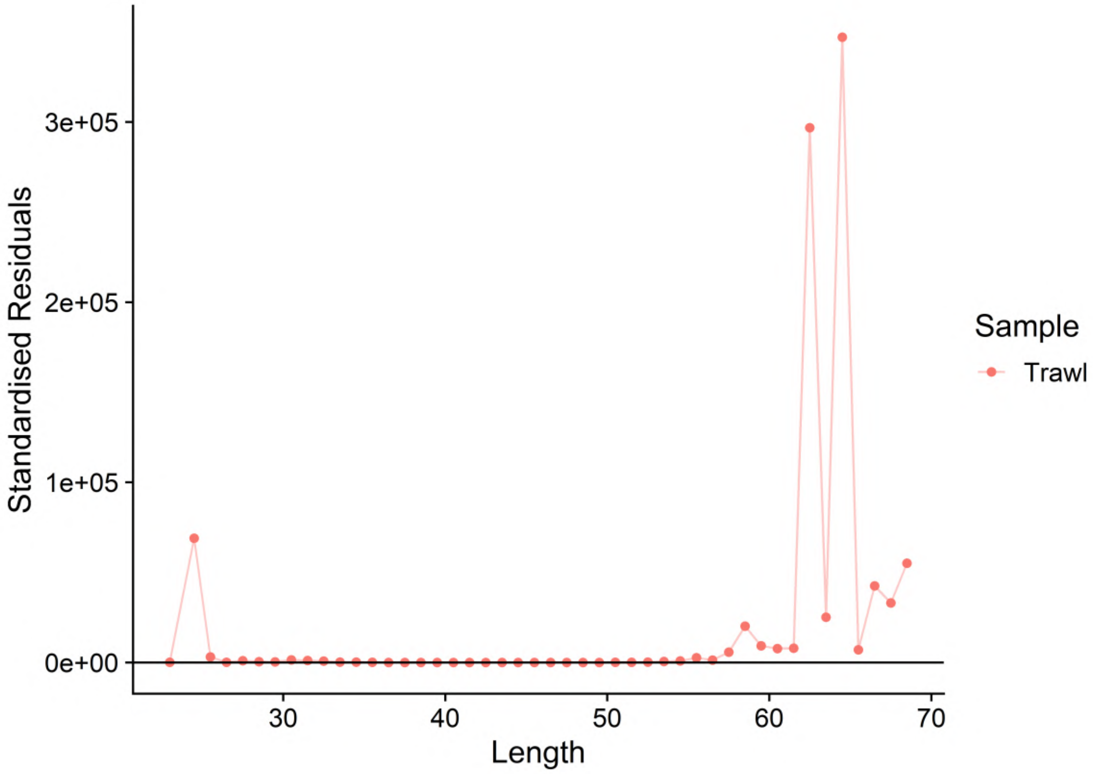
Observed and expected frequency for the maximum posterior density fit with mixed selectivity, constant natural mortality and logistic trawl selectivity.



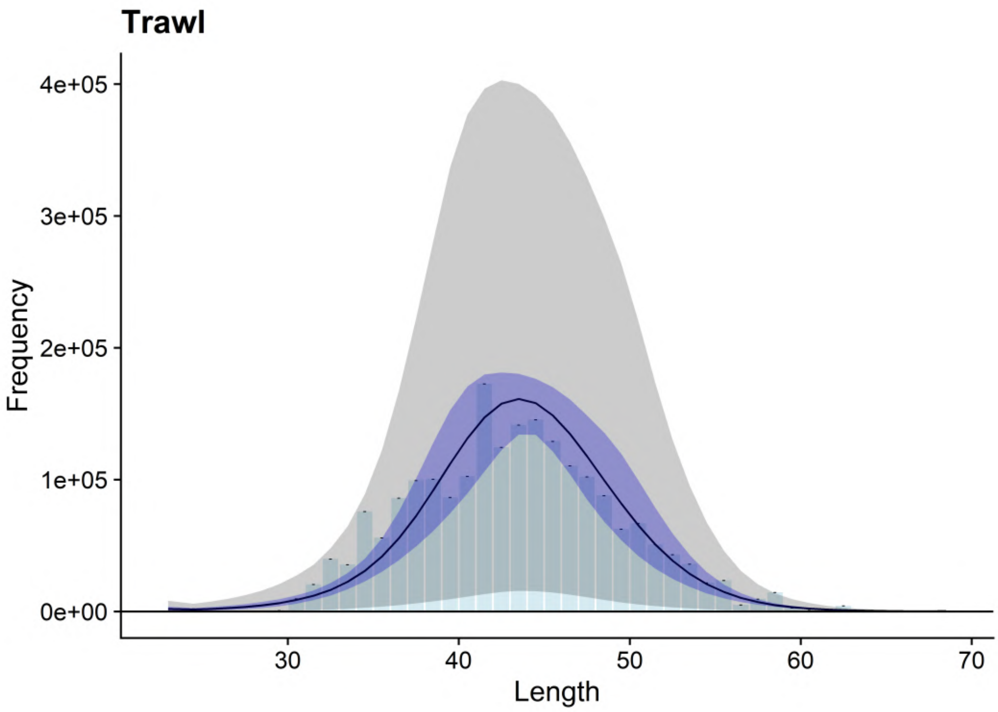
Model parameter estimates based on maximum posterior density fit.

Parameter	Value
Linf	71.400
Galpha	100.000
Mk	1.530
Fk[1]	1.530
Sm[1]	43.500
Sm[2]	0.055
NB_phi	100.000
Gbeta	1.401
lp__	-324,341.798
SPR[1]	0.672
B_B0[1]	0.803
YPR[1]	84.357

Standardised residuals for the logistic selectivity mixture model.



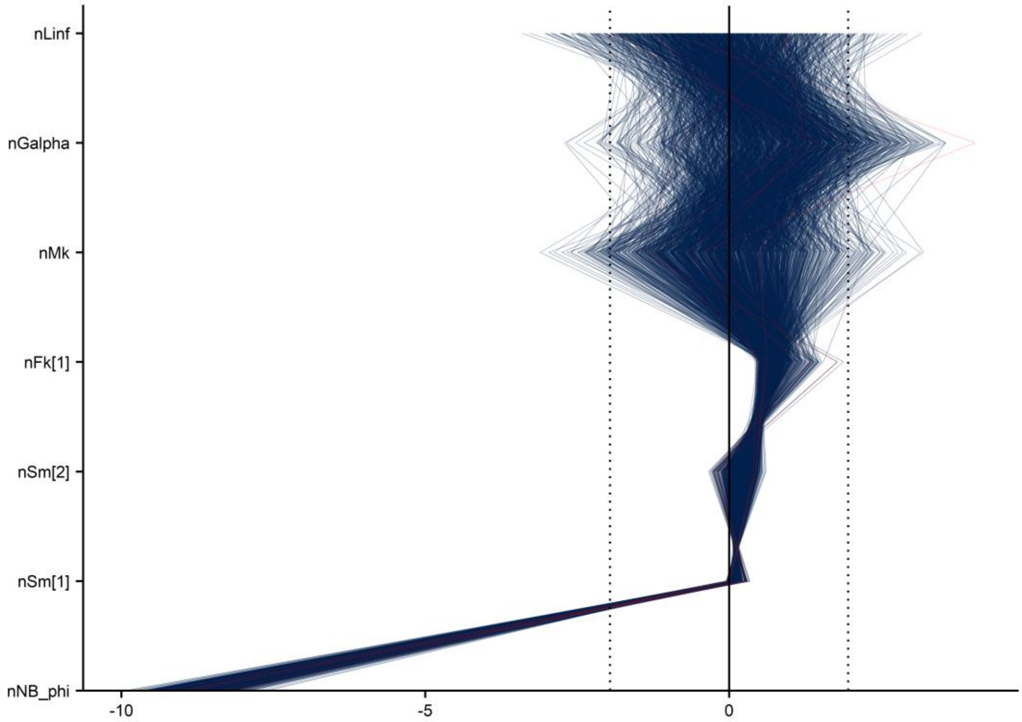
MCMC Fit



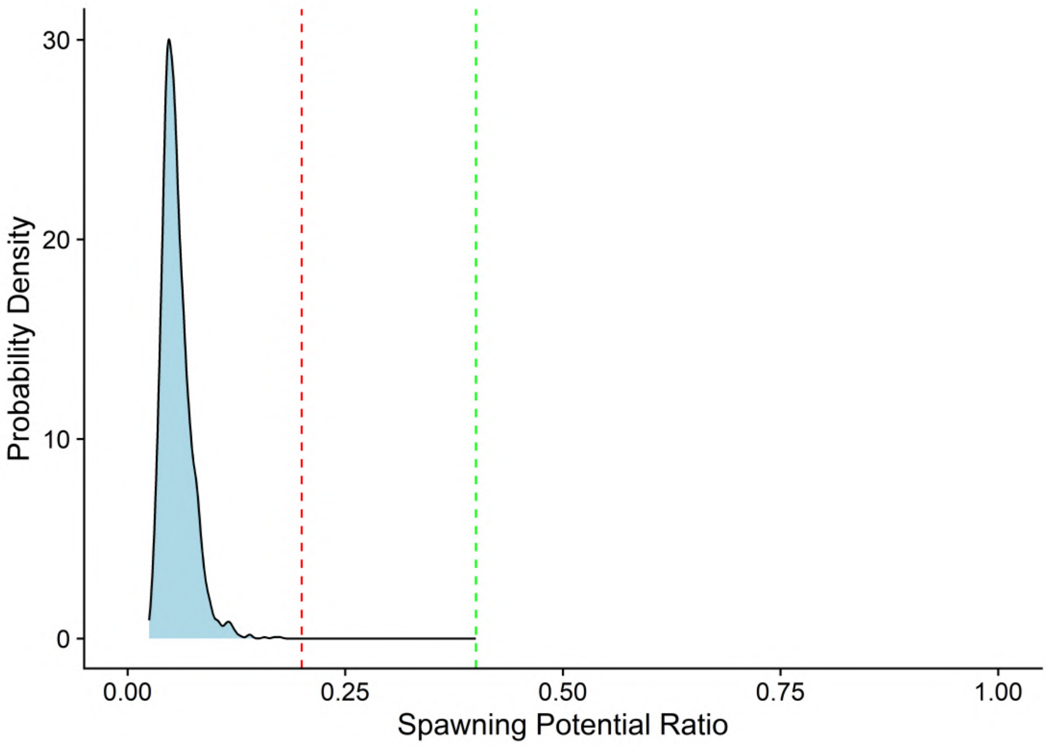
MCMC parameter estimates with the effective sample size

Parameter	Mean	SD	N (eff)	Rhat
Linf	71.236	1.007	1,886	1.000
Galpha	123.345	32.023	1,641	0.999
Mk	1.534	0.150	1,847	1.001
Fk[1]	7.350	4.117	242	1.012
Sm[1]	43.841	4.061	262	1.011
Sm[2]	0.350	0.071	419	1.006
NB_phi	1.219	0.183	1,558	1.000
Gbeta	1.732	0.452	1,621	0.999
SPR[1]	0.057	0.017	518	1.004
lp__	-516.400	1.957	625	1.001

Bayesian Model



Spawning potential ratio



Fishblicc Preliminary Assessment of Groundfish Stock in the Gulf of Paria, Trinidad: Artisanal and Non-Artisanal Trawl Fleets

Using Bayesian Length-Based Methods (fishblicc)
Based on Data Collected Under the REBYC-II Project at sea observer programme

Presented at the
CRFM Continental Shelf Fisheries Working Group (CSWG)
Data-limited assessment of groundfish stocks for Suriname, Guyana and Trinidad & Tobago
31 March – 4 April 2025 | Paramaribo, Suriname

Asha Hargreaves – Fisheries Researcher
Marc Bejai – Fisheries Officer
Fisheries Division, Ministry of Agriculture, Land and Fisheries
Trinidad and Tobago

Preliminary fishblicc Assessment for Groundfish (Bycatch) from Artisanal & Non-Artisanal Trawl Fleets in Trinidad – Gulf of Paria

- **Species Assessed:** *Cynoscion leiarchus* (White Salmon)
  - Coastal fish found in the western Atlantic from Brazil to the Gulf of Mexico
  - Vital to local food supply and livelihoods of small-scale fishers
- **Fishery Context:**
  - Caught as bycatch in Trinidad and Tobago’s shrimp trawl fisheries
  - Harvested by artisanal and non-artisanal fleets (single stern & double-rigged)
- **Assessment Data:**
  - Time Frame: 2018–2023
  - Source: Artisanal & Non-Artisanal shrimp trawl fleets
  - Focus: Groundfish bycatch in Gulf of Paria, Trinidad
- **Assessment Objective:**
  - Apply fishblicc Bayesian length-based catch curve model
  - Improve understanding of fishery dynamics and support stock assessments

Species Profile

- **Species:** *Cynoscion leiarchus (Cuvier ,1830)*

- **Maximum Length:** 90.8 cm
- **Distribution:** Western Atlantic
- **Habitat:** Nearshore coastal waters, demersal zones

Data collection

- **Source**: ***Data collected aboard shrimp trawlers*** (Artisanal and Non-artisanal)
- ***At-Sea Observers recorded species, fish lengths, and catch composition.***

- **Sampling Composition**
  - 50% of marketable bycatch sampled
  - 10 lbs of shrimp sampled from 1 haul per trawler trip
  - Bycatch discards sampled: all "Species of Interest" measured in sample; Species "other than Species of Interest" subsampled (5 lbs)

- **Shrimp Sorting**
  - Sorted/measured by **species** and **sex**

- **Measurement Process**
  - Categorical weight recorded
  - Individual total lengths measured

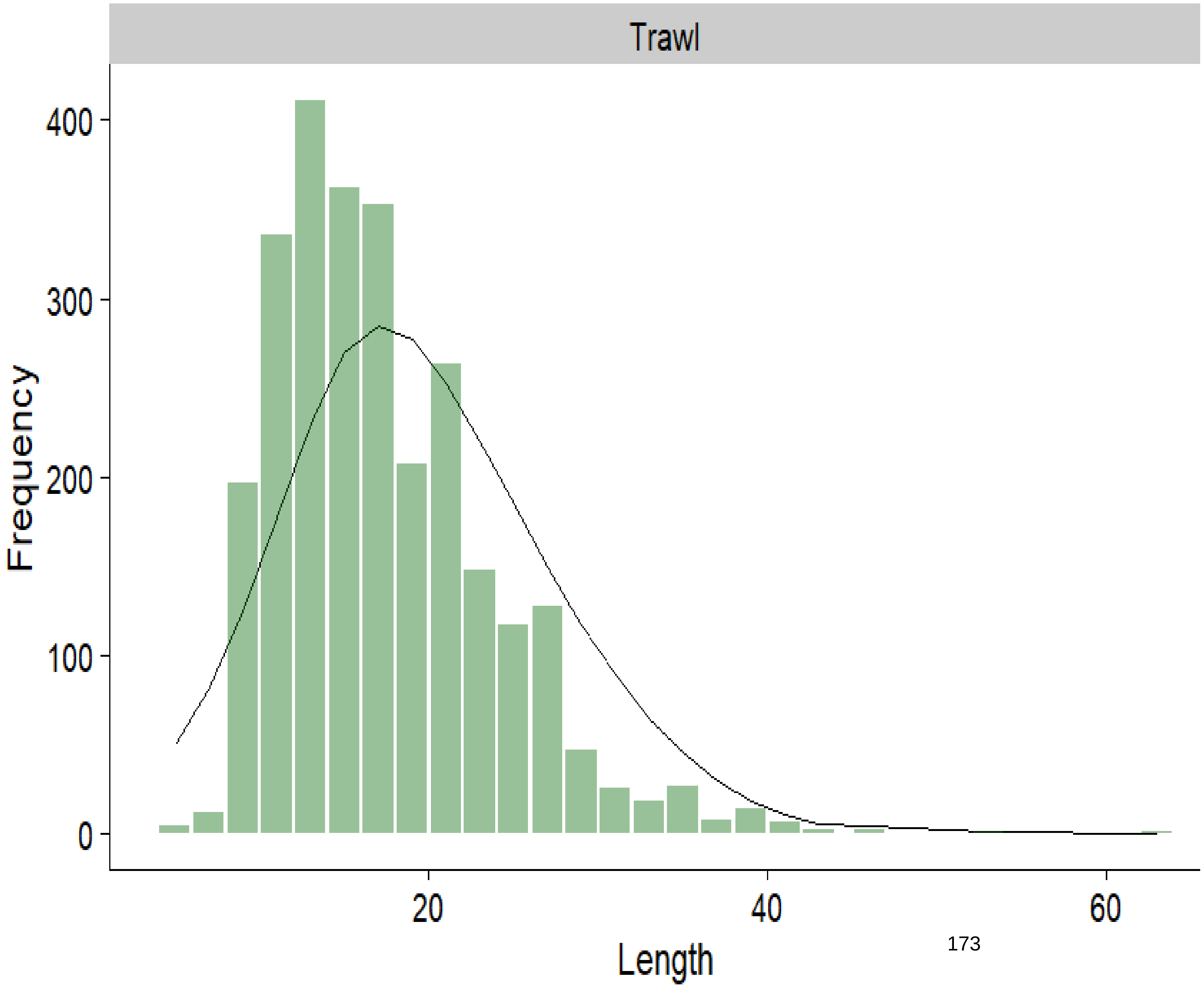
Spawning Potential Ratio (SPR)

SPR Value: 0.0489 (4.89%)

Indicates very low spawning biomass.

High fishing pressure present.

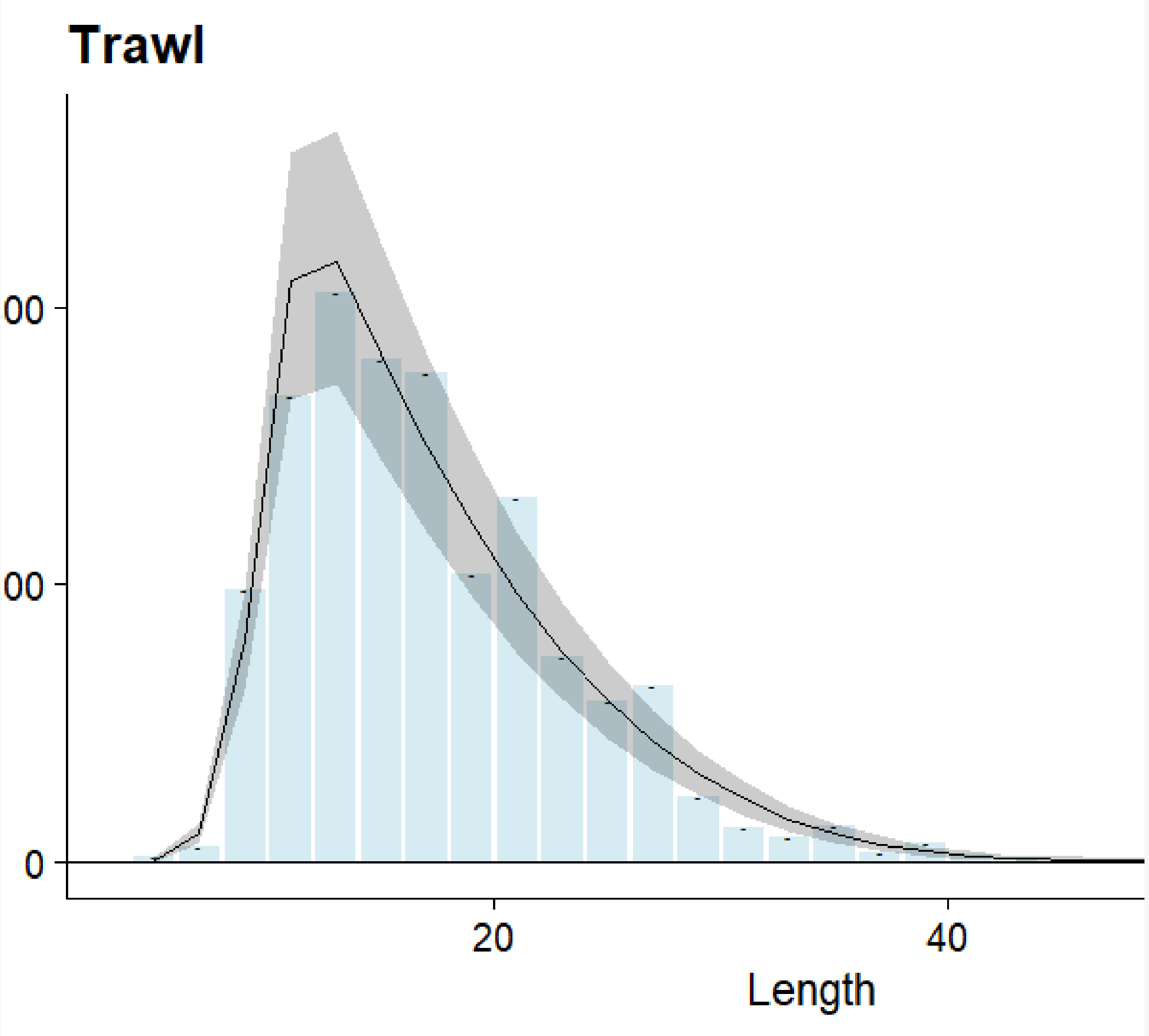
Target SPR: 20%–40% for sustainability.



Prior

Plot Interpretation:

- The histogram (green bars) represents the observed frequency of individual fish lengths collected from trawl data.
- The smooth black line shows the expected frequency distribution derived from the prior means of biological parameters (e.g., growth, natural mortality, selectivity).



Posterior fit

- *Observed Length Frequencies*
- The model provided a reasonable fit to the observed data.
- Maximum posterior density fit assumed:
  - Mixed selectivity
  - Constant natural mortality
  - Logistic trawl selectivity
- Generated using `plot_posterior(res)` from the `fishblicc` package.

Challenges in Fisheries Data Collection

Trust in Observers – Ensuring the accuracy and reliability of observer-collected data.

Observer Retention – Difficulty retaining experienced observers, impacting long-term data quality.

Data Gaps – Resulting from contract-based observer employment.

Inconsistent sampling effort and limited observer coverage.

Budget and staffing limitations.

Model Parameters-fishblicc results

- Natural mortality (M)
- Growth rate (K)
- Length-at-maturity (L50)
- Selectivity coefficients

PARAMETER	VALUE
LINF	46.6641843
GALPHA	69.5838994
MK	1.5465289
FK[1]	2.4082257
SM[1]	9.8049400
SM[2]	1.1917089
NB_PHI	39.6028417
GBETA	1.4911629
LP_	-98.3267686
SPR[1]	0.0489451

Summary of fishblicc results

- **Interpretation of SPR[1] = 0.0489451:**
  - A value of **0.0489 (4.89%)** means that the spawning biomass under current fishing pressure is only **4.89% of what it would be in an unfished population.**
  - Sustainable fisheries typically aim for **SPR > 20%–40%**, depending on management goals.

PARAMETER	VALUE
LINF	46.6641843
GALPHA	69.5838994
MK	1.5465289
FK[1]	2.4082257
SM[1]	9.8049400
SM[2]	1.1917089
NB_PHI	39.6028417
GBETA	1.4911629
LP_	-98.3267686
SPR[1]	0.0489451

Preliminary JABBA Assessment for Shrimp from Artisanal & Non-Artisanal Trawl Fleets in Trinidad Gulf of Paria

CRFM Continental Shelf Fisheries Working Group (CSWG)

Data-limited assessment of groundfish stocks for Suriname, Guyana and Trinidad & Tobago

31 March – 4 April 2025

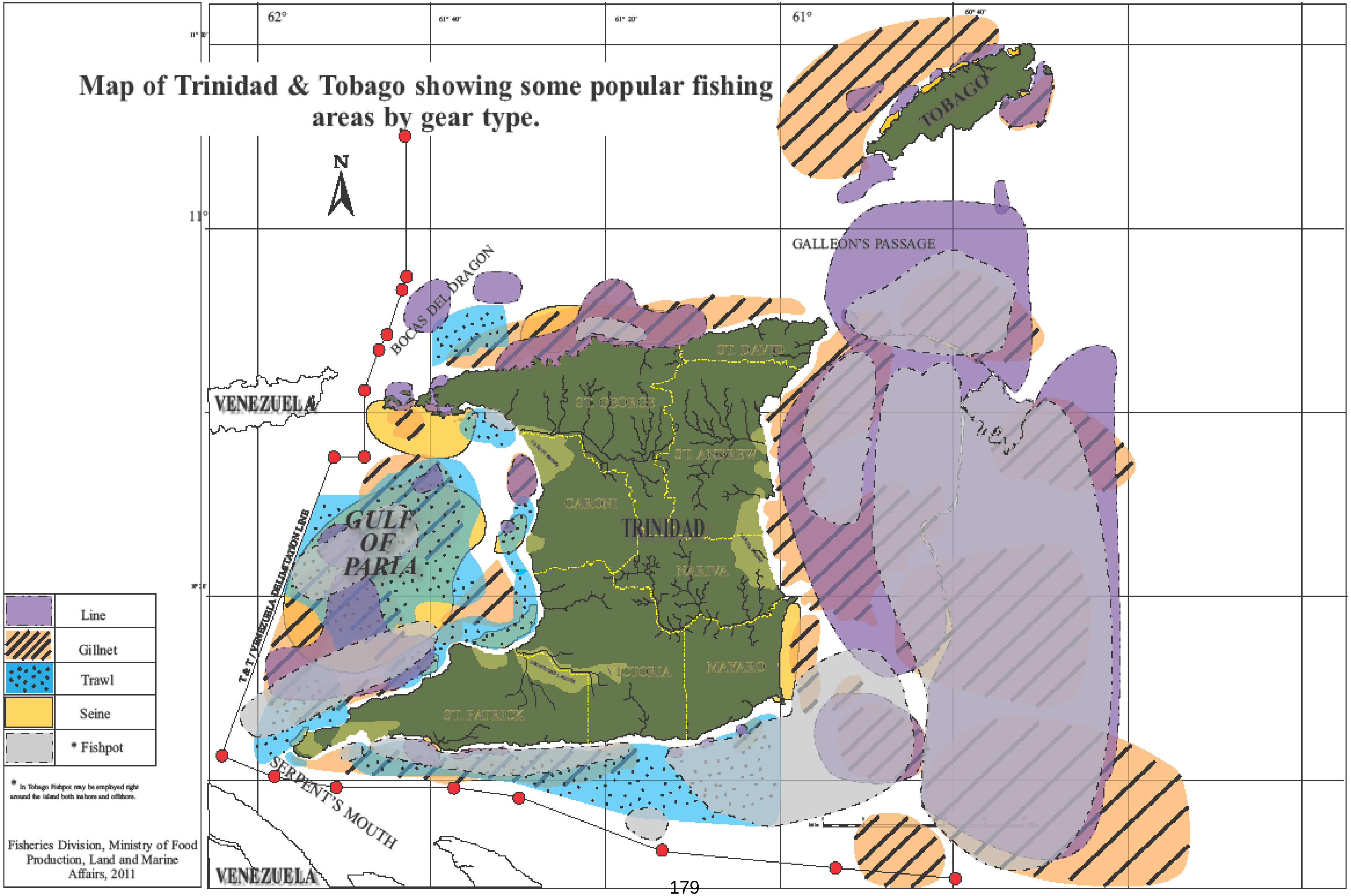
Paramaribo, Suriname

Lara Ferreira

Fisheries Officer

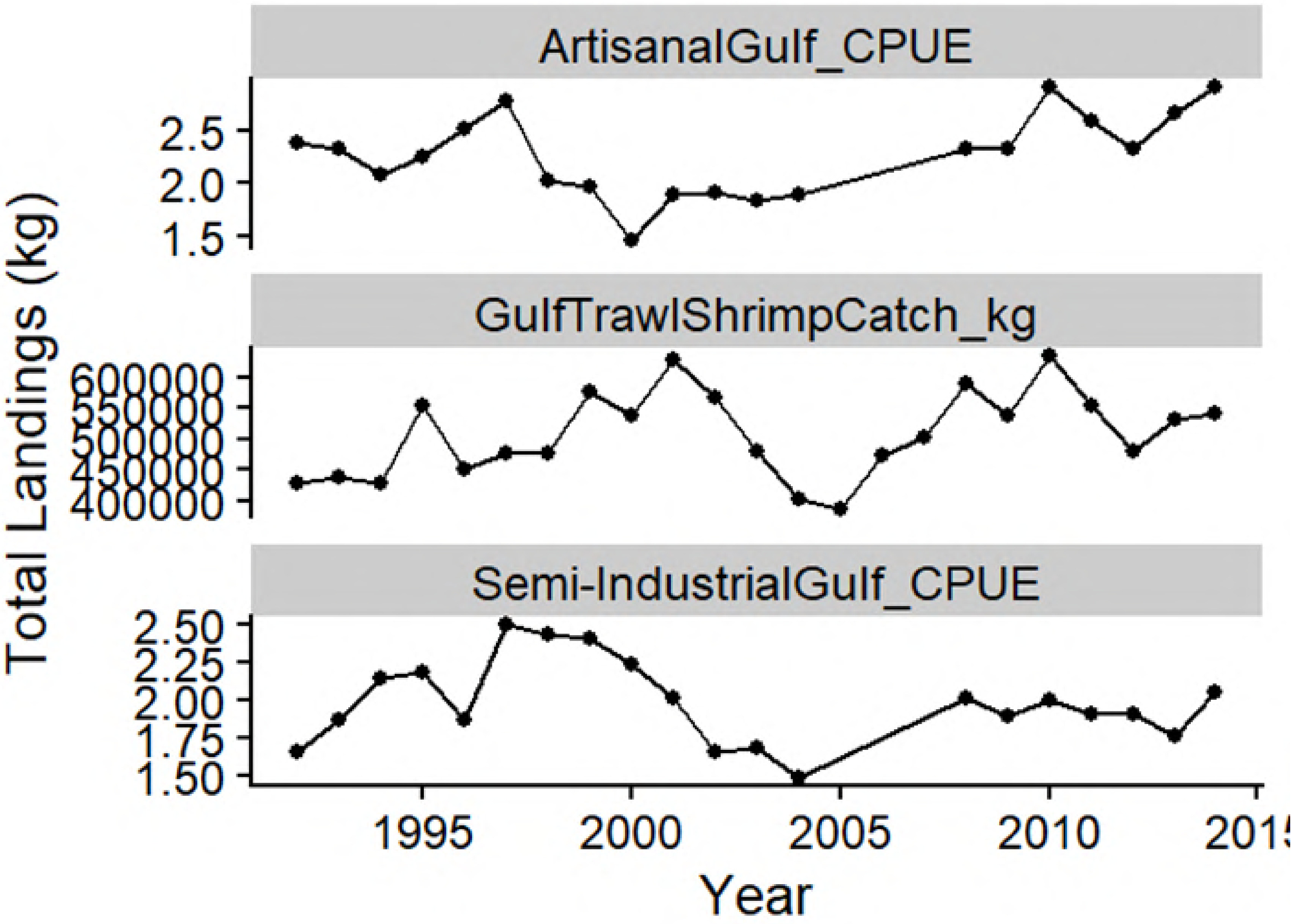
Fisheries Division, Ministry of Agriculture, Land and Fisheries

Trinidad and Tobago


Map of Trinidad & Tobago showing some popular fishing areas by gear type.
62°
61°
11°
N
GALLEON'S PASSAGE
TOBAGO
BOCAS DEL DRAGON
VENEZUELA
ST. DAVID
ST. GEORGE
ST. ANDREW
CARONI
TRINIDAD
NARIVA
VICTORIA
MAYARO
ST. PATRICK
GULF OF PARIA
T & T / VENEZUELA DELIMITATION LINE
SERPENT'S MOUTH
VENEZUELA
Line
Gillnet
Trawl
Seine
* Fishpot
* In Tobago Fishpot may be employed right around the island both inshore and offshore.
Fisheries Division, Ministry of Food Production, Land and Marine Affairs, 2011

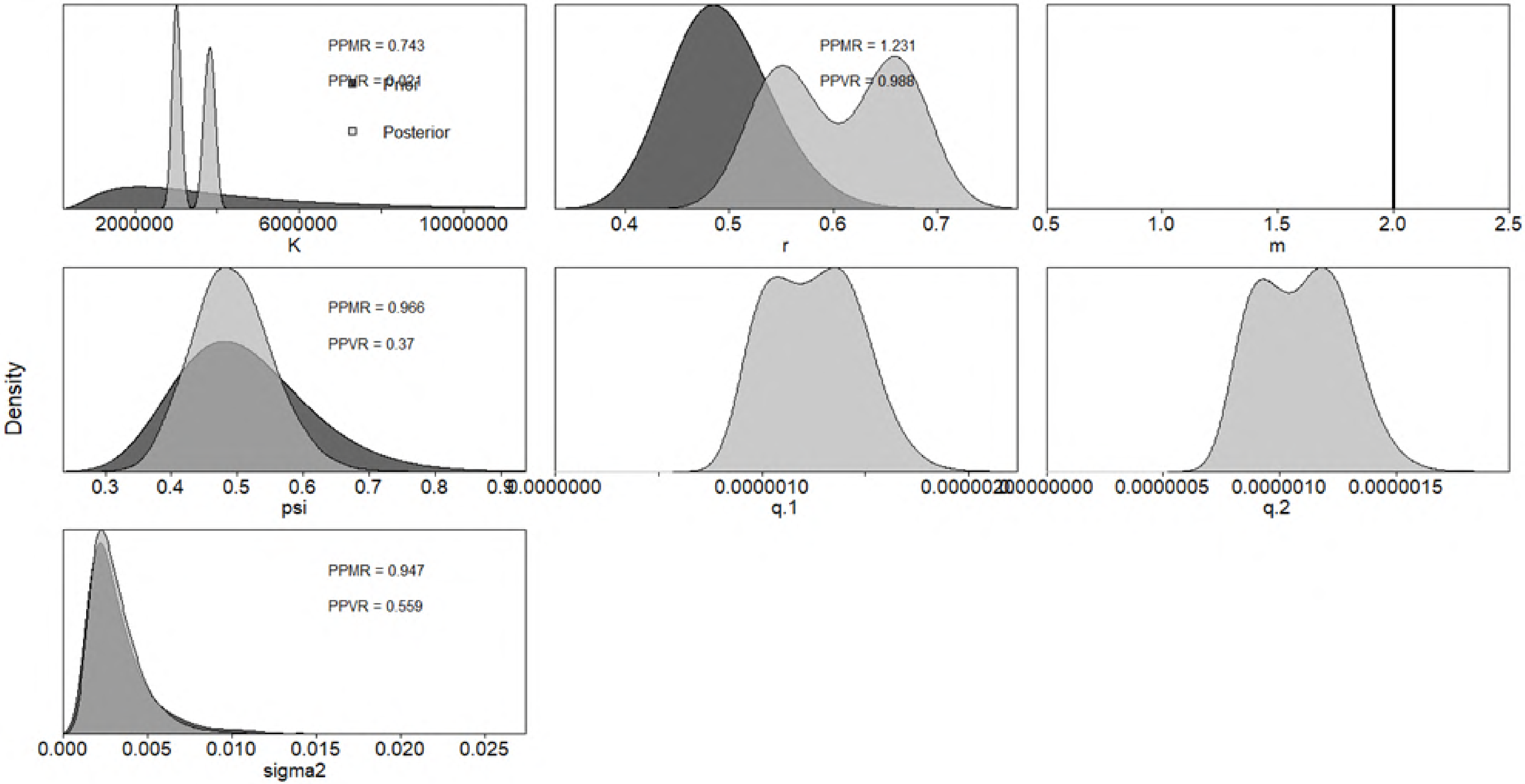
Preliminary JABBA Assessment for Shrimp from Artisanal & Non-Artisanal Trawl Fleets in Trinidad Gulf of Paria

- **5 species of Shrimp** *(Farfantepenaeus subtilis, F. notialis, Litopenaeus schmitti, Xiphopenaeus kroyeri, F. brasiliensis)*
- Landings data for **1992-2014**
- Artisanal & Non-Artisanal (single stern & double-rigged) trawl fleets
- Assessment restricted to shrimp captured in **Gulf of Paria**, Trinidad
- Shrimp on south coast more likely to be shared with Venezuela (for which no data available to us at this time)
- **CPUE indices** used for **Artisanal & Non-Artisanal single stern trawl fleets** (better data for these fleets)



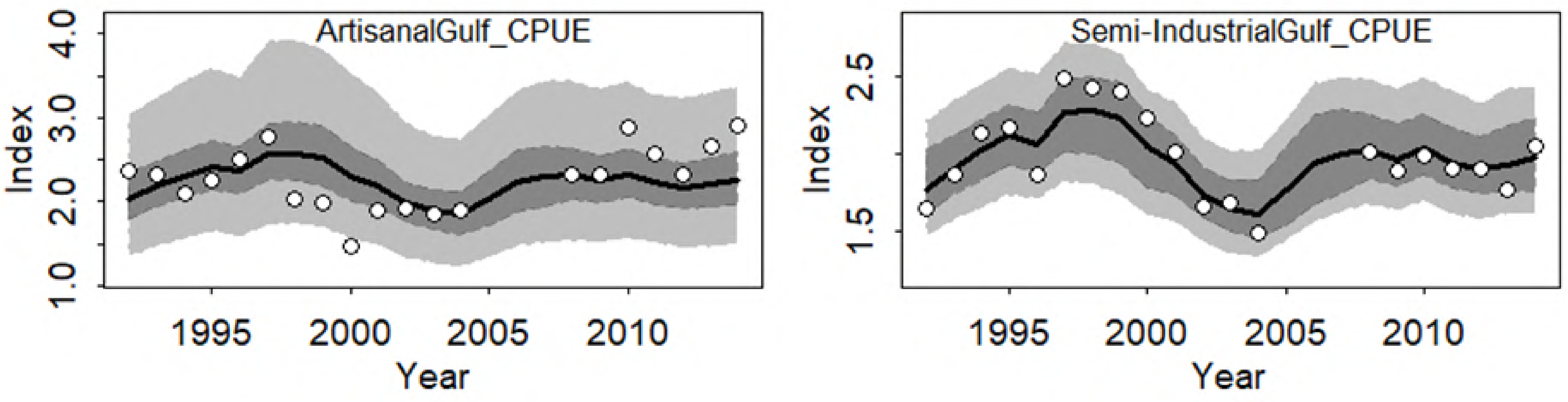
ArtisanalGulf_CPUE
2.5
2.0
1.5
GulfTrawlShrimpCatch_kg
600000
550000
500000
450000
400000
Semi-IndustrialGulf_CPUE
2.50
2.25
2.00
1.75
1.50
1995
2000
2005
2010
Total Landings (kg)
Year

Prior and posterior density plots

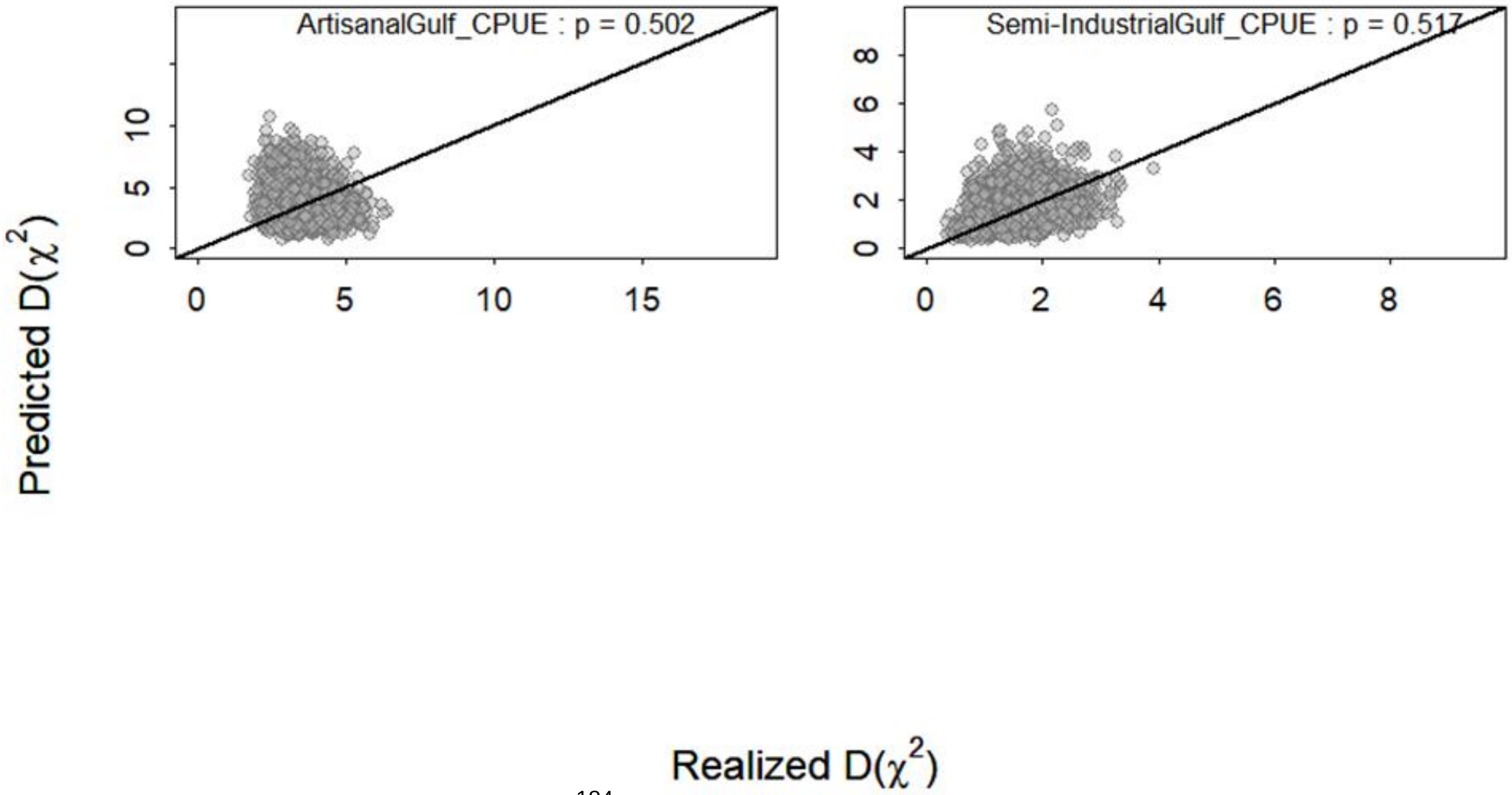


CPUE fits for the base model

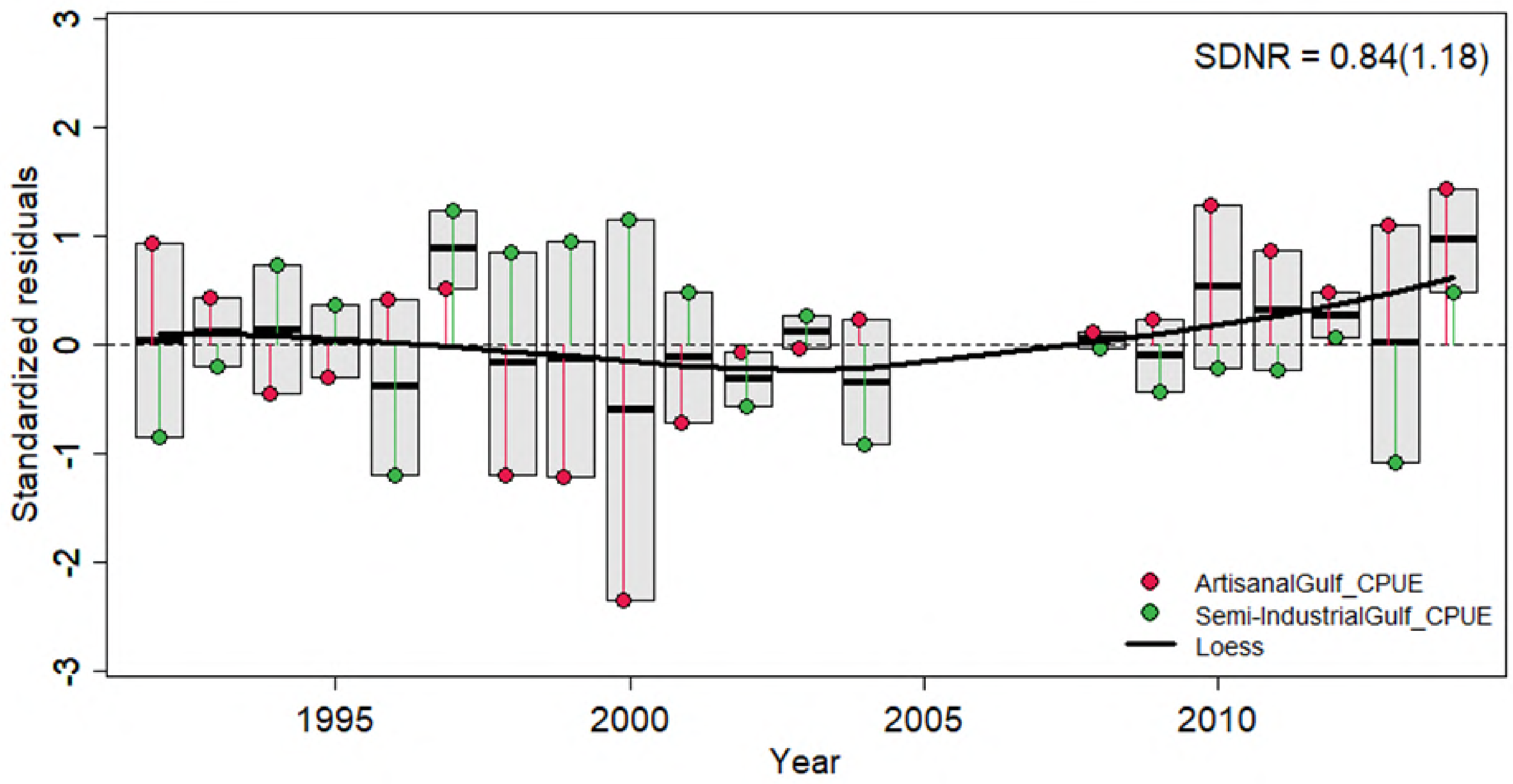
- better fit for the CPUE index from non-artisanal single stern trawlers.
- some outliers in artisanal fleet CPUE index.



Posterior predictive checks for the base model



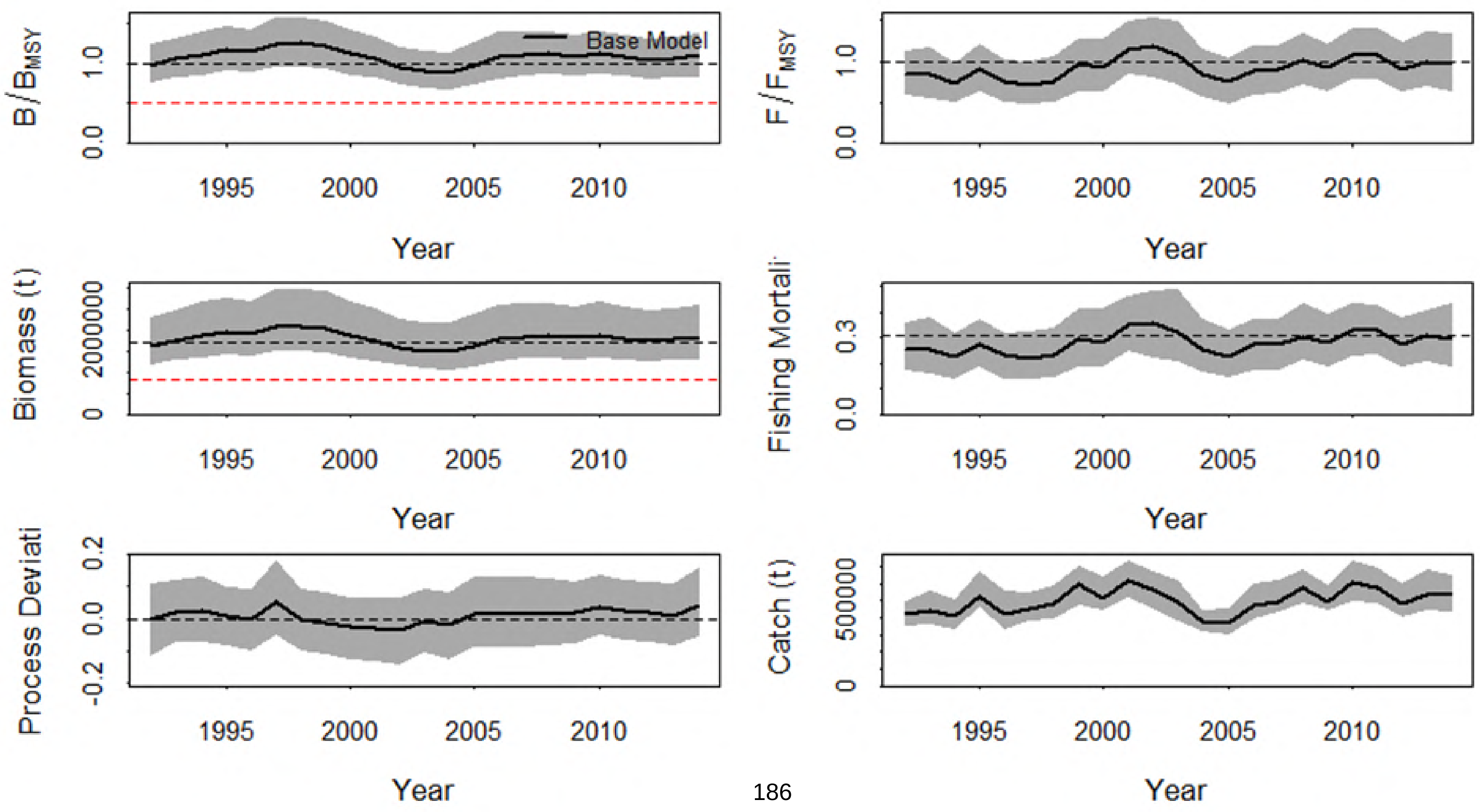
Standardised residual plots for the base model



Summary of Results for the base model

- B/Bmsy plot shows shrimp stock biomass remained quite stable varying around Bmsy
- F/Fmsy plot shows fishing mortality varied around the Fmsy
- more or less sustainable exploitation

Note: Absolute biomass & Catch is in kg (not tonnes as labelled in pre-set plots provided by JABBA)



Summary of Results

	mu	lci	uci
K kg	3381918.6987750	2966197.340379	3902265.9838860
r	0.6089497	0.501761	0.7089136
psi	0.4903466	0.383552	0.6178487
sigma.proc	0.0530000	0.035000	0.0850000
m	2.0000000	2.000000	2.0000000
Hmsy	0.3040000	0.251000	0.3540000
SBmsy	1690959.3490000	1483098.670000	1951132.9920000
MSY kg	509763.6710000	455959.180000	575907.8040000
bmsyk	0.5000000	0.500000	0.5000000
P1992	0.4890000	0.385000	0.6120000
P2014	0.5450000	0.423000	0.6830000
B_Bmsy.cur	1.0900000	0.846000	1.3650000
H_Hmsy.cur	0.9640000	0.657000	1.3350000

Surinamese gillnet and trawl data of *Cynoscion virescens* (Kandratiki)

Gillnet data was gathered at landing sites by **LVV** data collectors

Trawl data was gathered on board of the trawlers by **LVV** onboard observers

To analyse the data we use R and we present in Quarto. The data is loaded from a comma delimited .csv file.

Firstly, the data is sorted.

After sorting the data is plotted in a simple plot

```
## here() starts at C:/Users/garfi/Desktop/STA_SAWG_Training/STA_SAWG_Training
## ── Attaching core tidyverse packages ──────────────────────── tidyverse 2.0.0 ──
## ✔ dplyr     1.1.4     ✔ readr     2.1.5
## ✔ forcats   1.0.0     ✔ stringr   1.5.1
## ✔ ggplot2   3.5.1     ✔ tibble    3.2.1
## ✔ lubridate 1.9.4     ✔ tidyr     1.3.1
## ✔ purrr     1.0.4
## ── Conflicts ────────────────────────────────────────── tidyverse_conflicts() ──
## ✖ dplyr::filter() masks stats::filter()
## ✖ dplyr::lag()    masks stats::lag()
## ℹ Use the conflicted package (<http://conflicted.r-lib.org/>) to force all conflicts to become errors
##
## Attaching package: 'flextable'
##
## The following object is masked from 'package:purrr':
##
##     compose
##
## Loading required package: viridisLite
##
## Attaching package: 'cowplot'
##
## The following object is masked from 'package:lubridate':
##
##     stamp
##
## Rows: 30118 Columns: 28
## ── Column specification ────────────────────────────────────────────────────────
## Delimiter: ","
## chr  (17): sample_id, sample_info_01, sample_info_02, species_code, species_...
## dbl   (8): total_length_cm, frequency, landing_site_code, fishing_gear_code,...
## dttm  (3): recording_date, departure_date, arrival_date
##
## ℹ Use `spec()` to retrieve the full column specification for this data.
## ℹ Specify the column types or set `show_col_types = FALSE` to quiet this message.
```

Sort everything for **Bottom trawl** and **Driftnet** in two columns
And the length data is converted from 1 cm increments to 3 cm increments.

```
## # A tibble: 26 × 2
##    length_group `sum(frequency)`
##           <dbl>            <dbl>
##  1           24              450
##  2           27             3001
##  3           30            19105
##  4           33            47452
##  5           36            53641
##  6           39            77330
##  7           42           103231
##  8           45           137891
##  9           48           134261
## 10           51           119479
## # ℹ 16 more rows
```

Expected length frequency based on the prior parameter means (line) plotted over the observed frequency (histogram). If necessary, these can be adjusted using the blip_sel function.

```
## Chain 1: Initial log joint probability = -12531
## Chain 1:     Iter      log prob        ||dx||      ||grad||       alpha      alpha0  # evals  Notes
## Chain 1:      499      -554.198    0.00048977       60.5279           1           1      547
## Chain 1:     Iter      log prob        ||dx||      ||grad||       alpha      alpha0  # evals  Notes
## Chain 1:      999      -541.557     0.0030134       106.079           1           1     1096
## Chain 1:     Iter      log prob        ||dx||      ||grad||       alpha      alpha0  # evals  Notes
## Chain 1:     1499      -541.042   0.000645844       33.5483           1           1     1650
## Chain 1:     Iter      log prob        ||dx||      ||grad||       alpha      alpha0  # evals  Notes
## Chain 1:     1999      -540.937    0.00146148       4.33162           1           1     2194
## Chain 1:     Iter      log prob        ||dx||      ||grad||       alpha      alpha0  # evals  Notes
## Chain 1:     2499      -540.923   0.000131299        2.5125      0.2294      0.2294     2747
## Chain 1:     Iter      log prob        ||dx||      ||grad||       alpha      alpha0  # evals  Notes
## Chain 1:     2706      -540.922   6.00283e-06     0.0655998           1           1     2974
## Chain 1: Optimization terminated normally:
## Chain 1:   Convergence detected: relative gradient magnitude is below tolerance
```

Observed and expected frequency for the maximum posterior density fit with mixed selectivity, constant natural mortality and logistic trawl selectivity.

Model parameter estimates based on maximum posterior density fit

Parameter	Value
Linf	93.042
Galpha	362.449
Mk	1.815
Fk[1]	1.999
Fk[2]	0.037
Sm[1]	47.194
Sm[2]	0.012
Sm[3]	71.413
Sm[4]	0.005

Parameter	Value
Sm[5]	83.772
Sm[6]	0.021
Sm[7]	59.425
Sm[8]	0.341
Sm[9]	1.595
Sm[10]	0.009
NB_phi	78.270
Gbeta	3.896
lp__	-540.922
SPR[1]	0.097
B_B0[1]	0.266
YPR[1]	293.246
YPR[2]	0.154

Expected length frequency based on the MCMC posterior parameters (line) for the base model plotted over the observed frequency (histogram).

Caribbean Regional Fisheries Mechanism

The CRFM is an inter-governmental organization whose mission is to "Promote and facilitate the responsible utilization of the region's fisheries and other aquatic resources for the economic and social benefits of the current and future population of the region".

The CRFM consists of three bodies – the Ministerial Council, the Caribbean Fisheries Forum and the CRFM Secretariat. CRFM members are Anguilla, Antigua and Barbuda, The Bahamas, Barbados, Belize, Dominica, Grenada, Guyana, Haiti, Jamaica, Montserrat, St. Kitts and Nevis, St. Lucia, St. Vincent and the Grenadines, Suriname, Trinidad and Tobago, and the Turks and Caicos Islands.

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