Marco teórico y estado del arte
Data Poor Models

Departamento Evaluación de Recursos,

División Investigación Pesquera

Contenidos de la Presentación

1. Contexto del taller de data Poor
2. Objetivos de la revisión
3. Estado de arte de modelos basados en pesquerías datos limitados
4. Experiencias en el DER
5. Modelo basado en Tallas. LIME (Rudd & Thorson, 2017). Erizo

- Nuevo formato de trabajo del DER.
- Se establece un grupo de trabajo dentro del DER referido a pesquerías limitadas en datos.
- Grupo Data Poor

Rayas, Brótulas, Cojinovas, Sardinas austral, crustáceos, etc.

Índice de Contenidos

IFOP

INSTI

Objetivo del Taller

- Realizar un review de los Modelos de Data Poor disponibles, y ordenar ideas relacionados a ellos.

- Iniciar la discusión sobre asesoría con este tipo de enfoques

Porque surge la necesidad de uso de este tipo de aproximaciones

En el mundo…

For example, the **Magnuson–Stevens Fisheries Conservation and Management Act** mandates fisheries managers in the United States to set catch limits based on the “best available science”, involving advice from stock assessment to inform those limits (Darcy and Matlock 1999; Methot et al. 2014). The **Marine Stewardship Council** similarly requires fisheries seeking certification to go through a stock assessment process to determine their sustainability (Gulbrandsen 2009).

En Chile…

Las necesidades de recomendaciones hacia la administración pesquera en relación al conocimiento del estado de los recursos ha incrementado en los últimos años, sin embargo, los diseños de monitoreo de IFOP no han sido enfocados en estos “nuevos” recursos, y por ende, la disponibilidad de datos es limitada.

El 2014 se establece un taller para estimar PBR para distintas pesquerías chilenas (Payá *et al.*, 2014) de acuerdo al nivel ("Tier System")

Nivel Tier 1
Stocks respecto a los cuales existe un modelo de evaluación estructurado a la talla o edad (Nivel 1ª y 1b)

→

Metódo 1
Metódo 2
Metódo 3
Metódo 4
Metódo 5

Nivel Tier 2
Poblaciones respecto de las cuales existe un modelo de dinámica (excedente de producción)

→

Metódo 6

Nivel Tier 3
Stocks respecto de los cuales existen datos insuficientes. Principalmente basados en capturas o tallas

→

Metódo 7
Metódo 8

(Ver documento…)

Se establecieron diferentes métodos para derivar Frms y Brms o proxies.

Tier 1- Stocks for which there is an age- or length-structured assessment model (e.g., Statistical Catch at Age type models) that provides usable estimates of present abundance. Within this tier, two distinct situations are common:

1a. MSY reference points (F_{MSY} and B_{MSY}) and the reference point B_{LIM} can be reliably estimated (or otherwise specified) from parameters estimated within the assessment model.

1b. Proxies for the reference points in 1a are chosen. The selection of these proxies should take account of uncertainty in the assessment model and the degree of resilience (or lack thereof) of the species.

Tier 2- Stocks for which there is a biomass dynamics model (also known as surplus production or stock-production model) or an empirical approach based on catch and relative abundance data. Other relevant data may also be used.

Tier 3- Stocks for which there is insufficient data allowing application of a population dynamics model. Empirical approaches based primarily on catch data (with no relative abundance data), life history traits, and/or survey data have to be used.

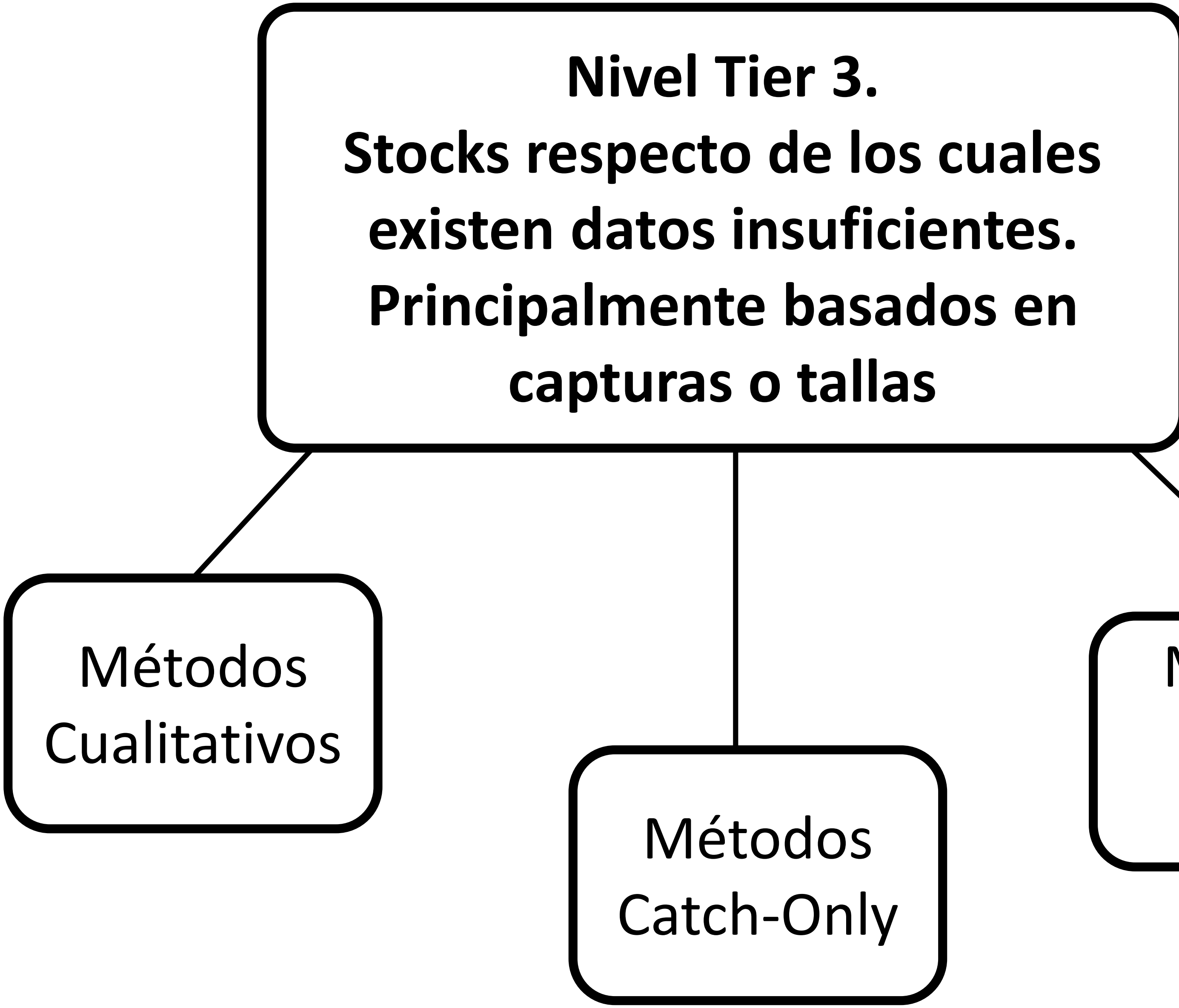
Método 7: (*para utilizar en Tier 3*)

Cuando los datos disponibles son insuficientes para permitir el modelamiento de la dinámica de la población, se pueden utilizar métodos empíricos para derivar los puntos de referencia proxy.

Se podrá derivar la mortalidad por pesca basada en puntos de referencia a partir de los parámetros del ciclo de vida. Por ejemplo, Zhou et al. (2012) proporciona los tres puntos de referencia en base a F a partir de un meta-análisis de 245 especies a nivel mundial (refiérase a las tablas 1 y 2, con los resultados de dicho trabajo). Algunos proxies más simples pueden ser F_{RMS} = 0.8 M (Thompson 1993), M, 2/3 M (Patterson 1992).

Método 8: (*para utilizar en Tier 3*)

Para las poblaciones que cuentan con una serie de tiempo confiable de datos de captura, se pueden aplicar métodos solo de captura para estimar la tasa de crecimiento de la población y la capacidad de carga; por ende se pueden obtener proxies F_{RMS} y B_{RMS} (Dick y MacCall 2011; Martell y Froese 2013; Zhou *et al.* 2012). **Esta es una nueva área de investigación.** El RMS estimado en sí tiende a ser más confiable que F_{RMS} y B_{RMS}. Puede ser necesario comparar los dos últimos puntos de referencia con otros métodos, tal como el Método 7 basado en rasgos de la historia de vida.


Nivel Tier 3.
Stocks respecto de los cuales existen datos insuficientes. Principalmente basados en capturas o tallas
Métodos Cualitativos
Métodos Catch-Only
Métodos Length-based

Métodos Catch Only

Modelo	SRA (Stock Reduction Analysis) (Kimura et al, 1984)	DCAD (McAll, 2009)	Catch MSY (Martel & Froese, 2011, Froese et al, 2017)	DB-SRA (Dick & McAll 2011)	Depletion Zhou (2013)	JABBA Just Another Bayesian Biomass Assessment (Winkler, 2020)
Supuestos	R equil. Cambios e la biomasa son catch	Ypot =0.5MBo. No mayor a M=0,2 Series largas	Mod prod de Shaeffer. Comb viables de r y K	the ratio of MSY fishing rate to M (Fmsy/M), the relative biomass at maximum latent productivity (Bmnpl = Bmsy/K), and the relative depletion level (BT/K) in a specific recent year T	Series de mínimo 10 años	Modelo de producción
Datos	Series de Capturas, M, h.	Series de tiempo Catch, M, Depletion	Series de capturas, prior r, K, resiliencia, depletion	Series de Captura, Producción latente derivida de la SSR	Datos de captura, nivel de agotamiento	Series de captura, Parámetros HV

Métodos Length based

Modelos	YPR (Beverton & Holt, 1957)	MODACT II (Canales, 2013)	LBSPR (Hodrick & Prince, 2015),	LBRA (Length-based risk analysis for assessing sustainability) (Ault et al, 2018)	LIME (Rudd & Thorson, 2017)	LBB (Length-based Bayesian biomass) (Froese et al, 2018)	BOLAS (Mildenberger et al., In press)
Supuestos	PBR basados en F. Control de esfuerzo y selectividad	Considera niveles de F asociados a la reducción de B0 deseada	Basado en tallas supuestas virginales.	Basado en agotamiento de biomasas	Basado en tallas supuestas virginales. Considera reclutamiento dinámico	The LBB estimation was implemented within the Bayesian Gibbs sampler software JAGS	Uses a bootstrapping framework and (multivariate) kernel density estimation for deriving quantities with 95% confidence intervals.
Datos	Estructuras de tallas, S, ojiva	Estr Tallas, h, S, M	Estructuras de talla, madurez, parámetros HV.	Estructuras de tallas, parámetros HV.	Estructuras de talla, madurez, parámetros HV.	Solo estructuras de tallas	Estr de tallas y parametros de HV.

Respecto a los modelos basados en tallas…

Razón del Potencial Reproductivo (SPR)

(o Spawning Potential Ratio)

Definición: Proporción de desovadores que quedan en el mar respecto de los desovadores originales (Goodyear, 1993)

Asumiendo un crecimiento vB la relación entre la biomasa y el promedio de longitud de una cohorte puede ser derivada de M/K.

How Much Spawning per Recruit is Enough?

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Mace, P. M. and M. P. Sissenwine. 1993. How much spawning per recruit is enough? p. 101–118. *In* S. J. Smith, J. J. Hunt and D. Rivard [ed.] Risk evaluation and biological reference points for fisheries management. Can. Spec. Publ. Fish. Aquat. Sci. 120.

$$\text{Razón Potencial Reproductivo (SPR)} = \frac{\text{Potencial Reproductivo}_{\text{capturado}}}{\text{Potencial Reproductivo}_{\text{no capturado}}}$$

No capturado: **700 eggs per 5 recruits**
EggsPR = 140

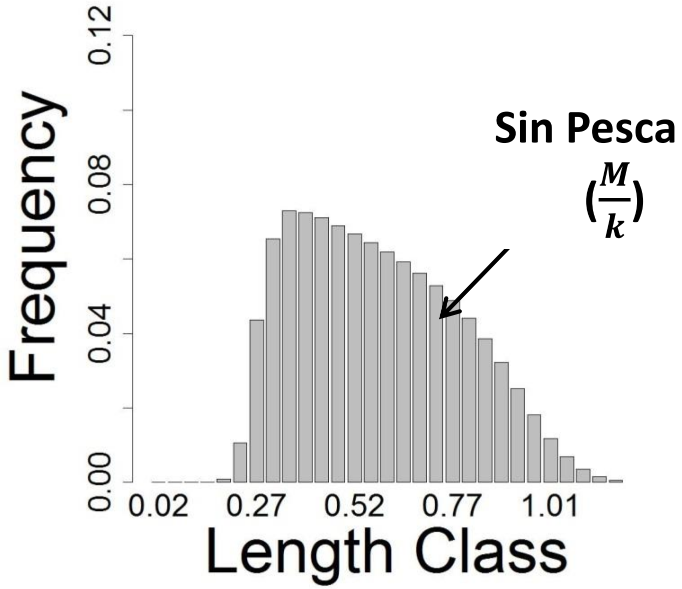
Capturado: **400 eggs per 5 recruits**
EggsPR = 80

SPR = 80/140 = 0.57 ó 57%

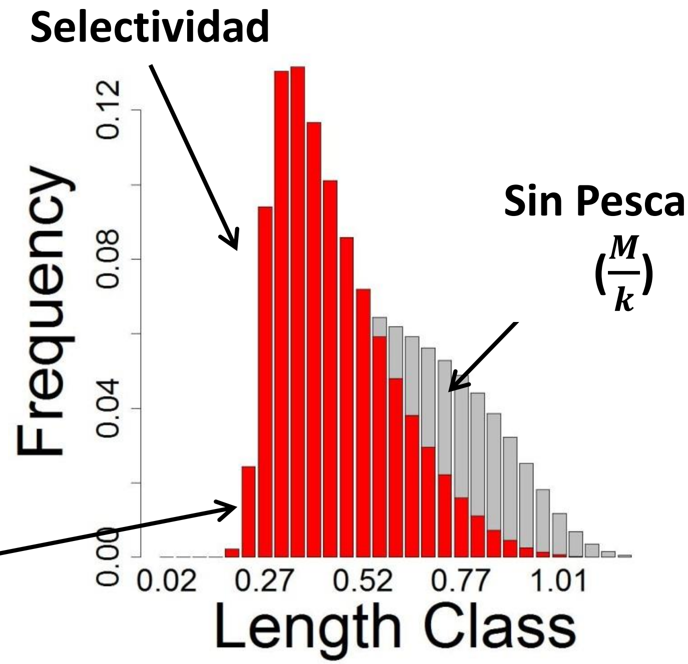
- Revision y meta-análisis de Puntos de Referencia basados en el SPR para teleosteos e invertebrados.
- **45% demersales y 50% pelágicos en Chile. Pero no se han establecido para bentónicos, por eso se assume un 40% del SPR. (**Mace & Sissenwine, 1993)
- Han sido reconcido internacionalmente como un proxy de MSY en US, Australia, NZ. (Restrepo 1999)

Conociendo *M/k*

Simulación de la composición de tallas del recurso sin pesca



Diferencia causada por mortalidad por Pesca (***F***)

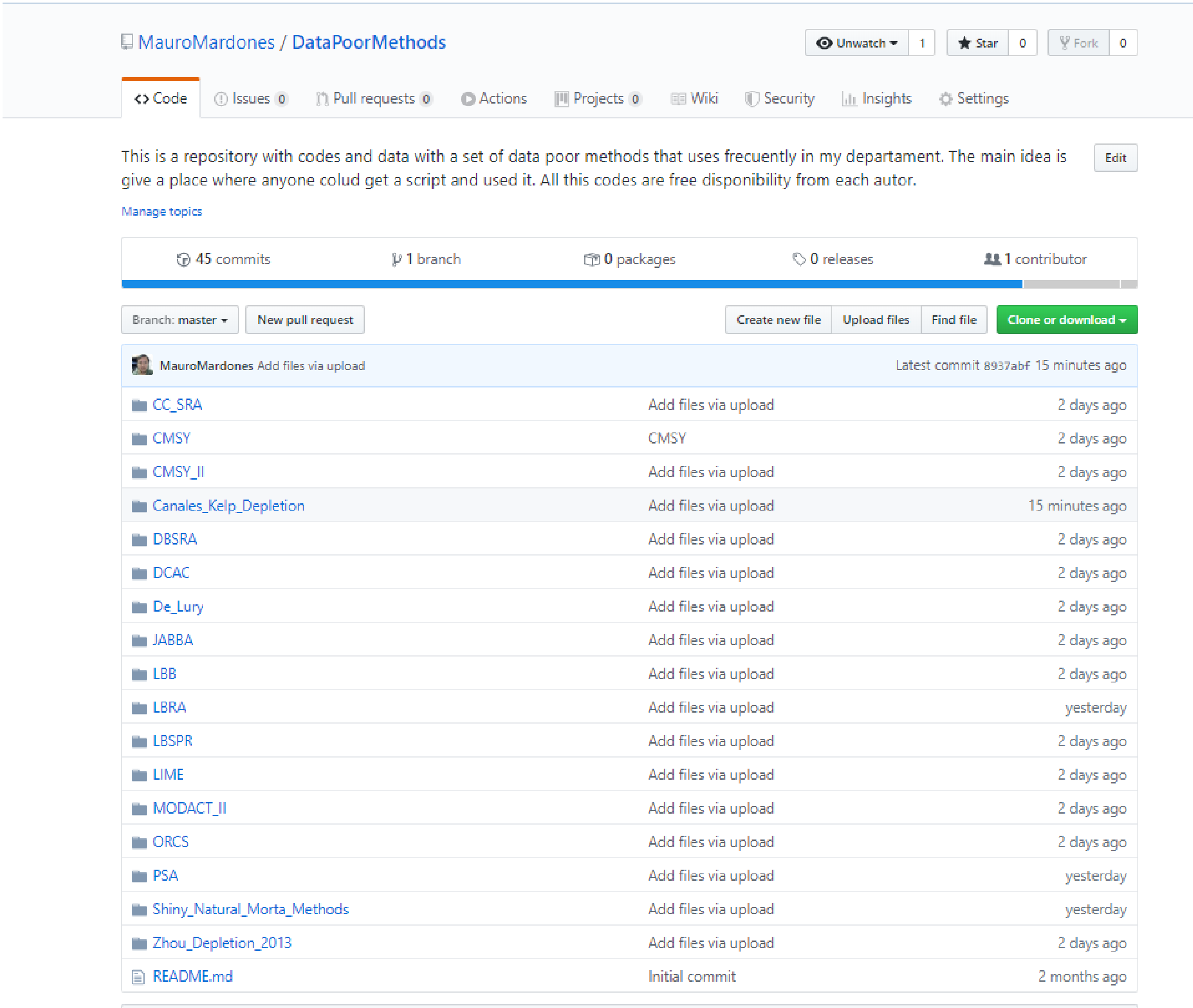


Estructura de tallas de la pesquería

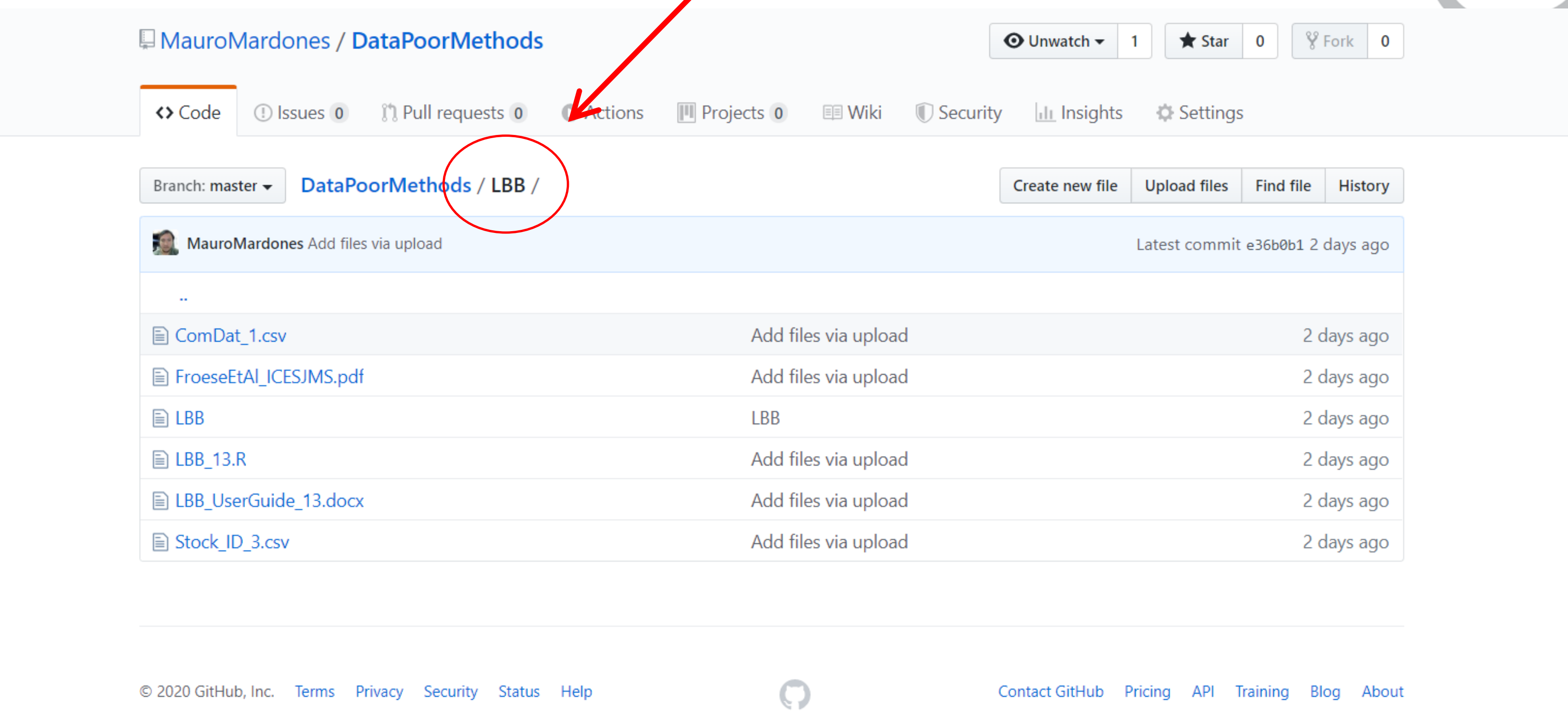
Modelos NO recomendados para selectividades que no sean logísticas

Experiencias de aplicación de modelos de data poor en el DER (IFOP)

Recurso	Zona	Método	Referencia	Reportado
Reineta	Nacional	CMSY	Froese, 2011	2015,2016
Sardina austral	X Región	Depletion	Zhou, 2013	2018
Jibia	Nacional	Depletion	Zhou, 2013	2015
Almeja	PM X y XI región)	LB-SPR	Hordyk et al., 2015	2017, 2018
Ostra	PM Bahía Ancud	CMSY	Froese, 2011	2016, 2017, 2018
Juliana	X Región	CMSY	Froese, 2017	2017, 2018
Raya	X Región	Depletion	Zhou, 2013	2017, 2018
Jaiba	X Región	LBSPR	Hordyk et al., 2015	2018
Algas (huiro)	PM III- VI Región	Depletion	Canales et al., 2018	2018
Navajuela	PM XIV Región	LBSPR	Hordyk et al., 2015	2018



https://github.com/MauroMardones/DataPoorMethods método


MauroMardones / DataPoorMethods
Unwatch 1
Star 0
Fork 0
Code
Issues 0
Pull requests 0
Actions
Projects 0
Wiki
Security
Insights
Settings
Branch: master
DataPoorMethods / LBB /
Create new file
Upload files
Find file
History
MauroMardones Add files via upload
Latest commit e36b0b1 2 days ago
..
ComDat_1.csv Add files via upload 2 days ago
FroeseEtAl_ICESJMS.pdf Add files via upload 2 days ago
LBB LBB 2 days ago
LBB_13.R Add files via upload 2 days ago
LBB_UserGuide_13.docx Add files via upload 2 days ago
Stock_ID_3.csv Add files via upload 2 days ago
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5. Modelo basado en Tallas. **LIME** (Rudd & Thorson, 2017).

Caso estudio: Erizo X Región

Estimation model – implemented using Template Model Builder

Inputs

Fixed parameters
1) Von Bertalanffy Linf and k
2) Maturity curve
3) Natural mortality
4) CV for length-at-age
5) CV for observed catch and index

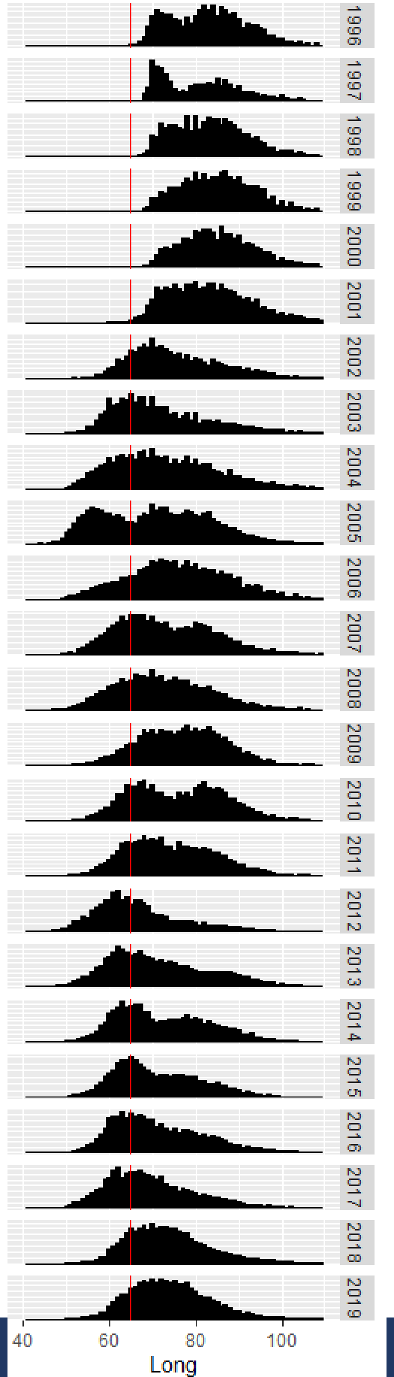
Data inputs
1) Length composition
2) Catch time series
3) Abundance index time series

Outputs

Estimated
1) Annual fishing mortality (fixed effect)
2) Global mean recruitment
3) Random effects on annual recruitment
4) Recruitment variation (σ_R)
5) Catchability coefficient
6) Logistic selectivity parameters

Performance measure
- SPR

Población Erizo X
Región analizada



Parámetros HV erizo

```
#Biology
MaxAge=12
L50=43.2 #Jaramillo
L95=65 # verrificar bibliografia
M=0.25
h=0.8
wla=0.0005
wlb=2.97973
K=0.139
t0=(-0.45)
Linf=136
LenCV=0.1
SigmaR=0.4
SigmaF=0.2
SigmaC=0.2
SigmaI=0.2
R0=1
qcoef=1e-5
start_ages=0
rho=0
nseasons=1
binwidth=2
S50=65
S95=70
```

- Mean-length mortality estimators (e.g., Gedamke and Hoenig 2006), first developed by Beverton and Holt (1957), assume that fishing mortality directly influences mean length of the catch and have been used for assessments in the US South Atlantic, Pacific islands, and Caribbean (Ehrhardt and Ault 1992; Ault et al. 2005, 2008; Gedamke and Hoenig 2006; Nadon et al. 2015).

- As measures of stock status, these length-based methods derive the spawning potential ratio (SPR) reference point, defined as the proportion of unfished reproductive potential at a given level of fishing pressure (Goodyear 1993).

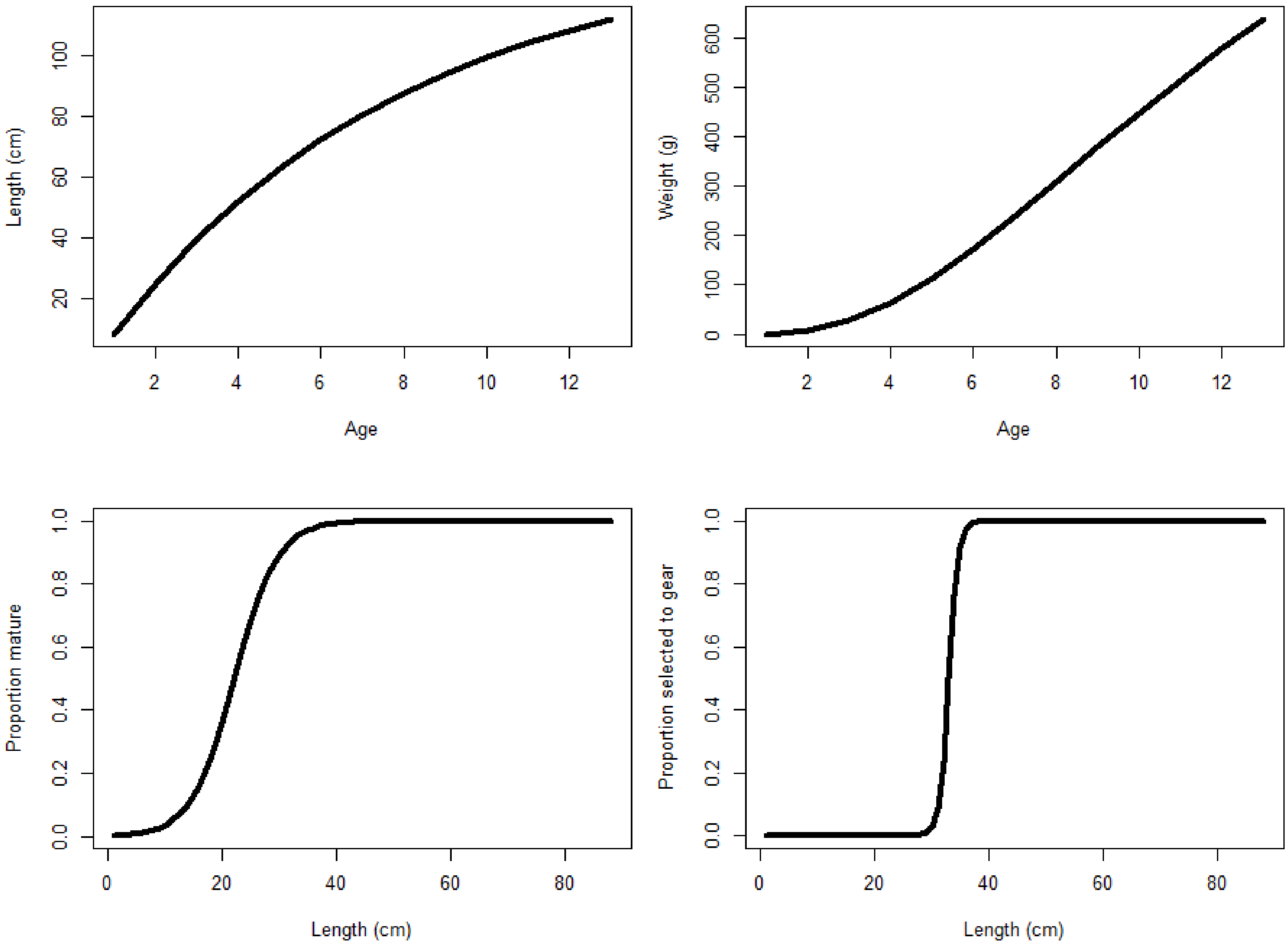
SUPUESTOS del LIME

- LIME relaxes the equilibrium assumptions of other length-based methods by estimating annual fishing mortality and recruitment variation (among other parameters), deriving annual recruitment as a random effect.

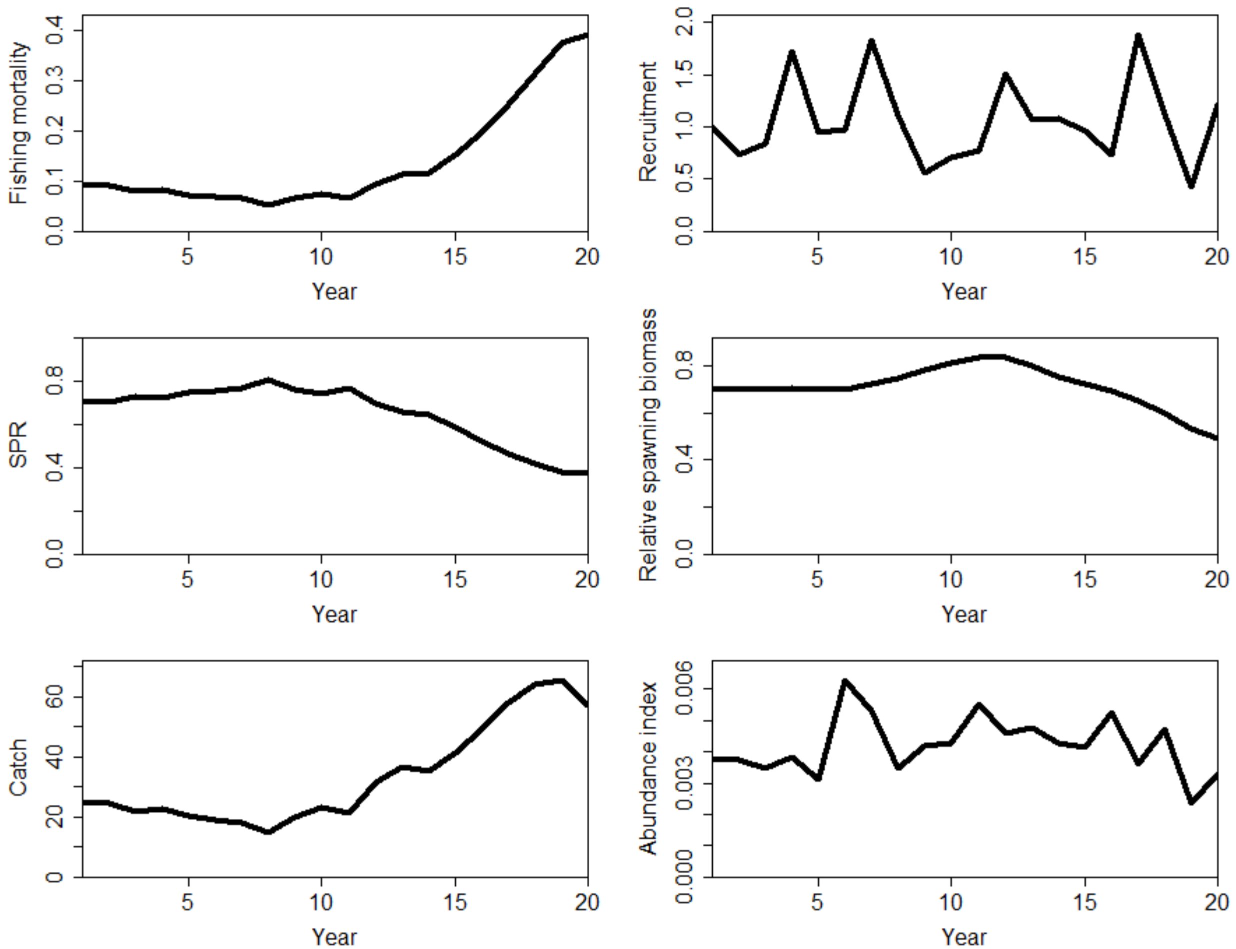
- assumes constant selectivity over time.

Step 1: Specify starting values

- biological,
- explotation and
- variations inputs


Length (cm)
Age
Weight (g)
Age
Proportion mature
Length (cm)
Proportion selected to gear
Length (cm)

Step 2: Data inputs LIME. Simulando datos

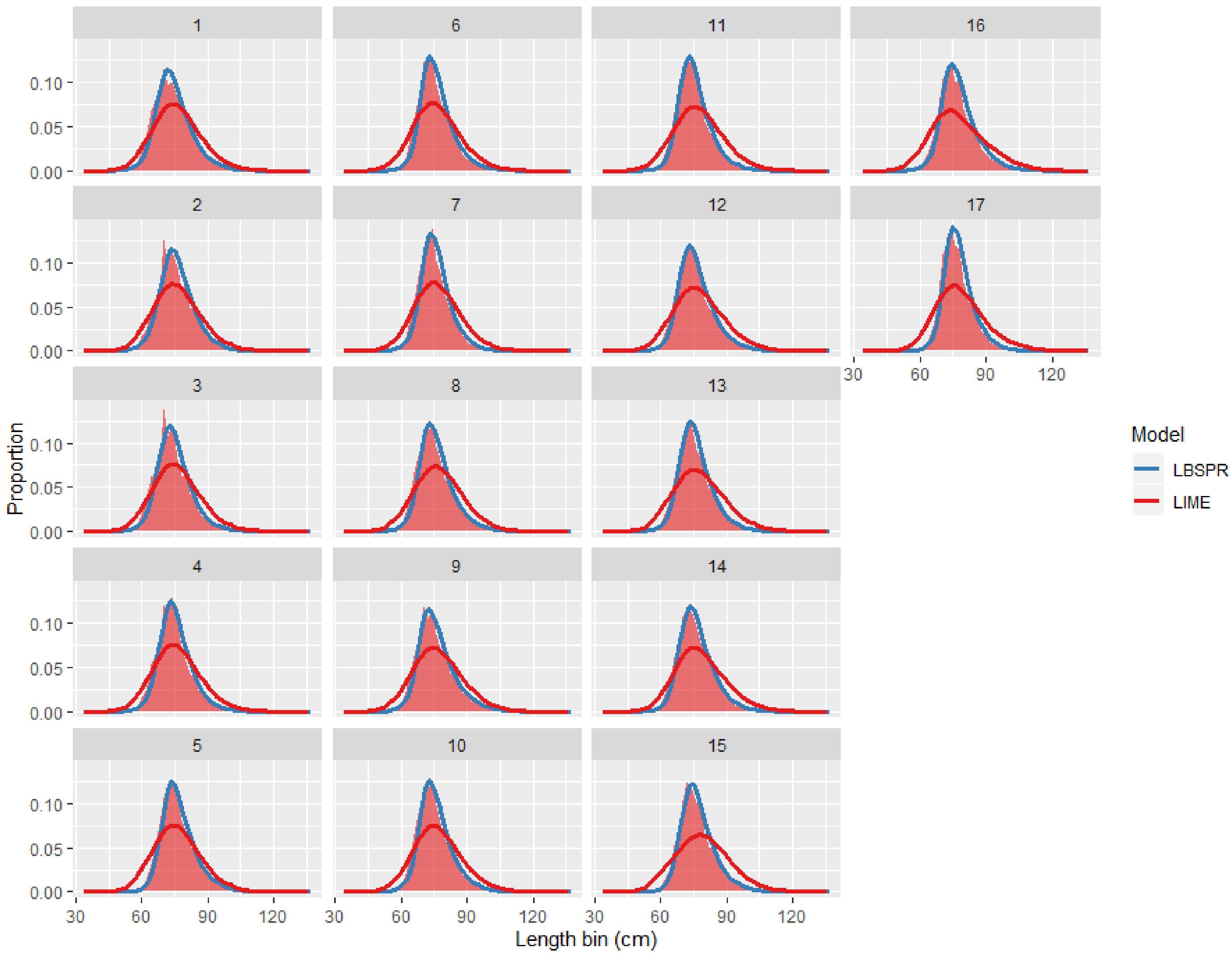


True population: fishing mortality mimicking an open access fishery, where effort is a function of spawning biomass, autocorrelated recruitment, spawning potential ratio (SPR), mean length, spawning biomass, and relative spawning biomass.

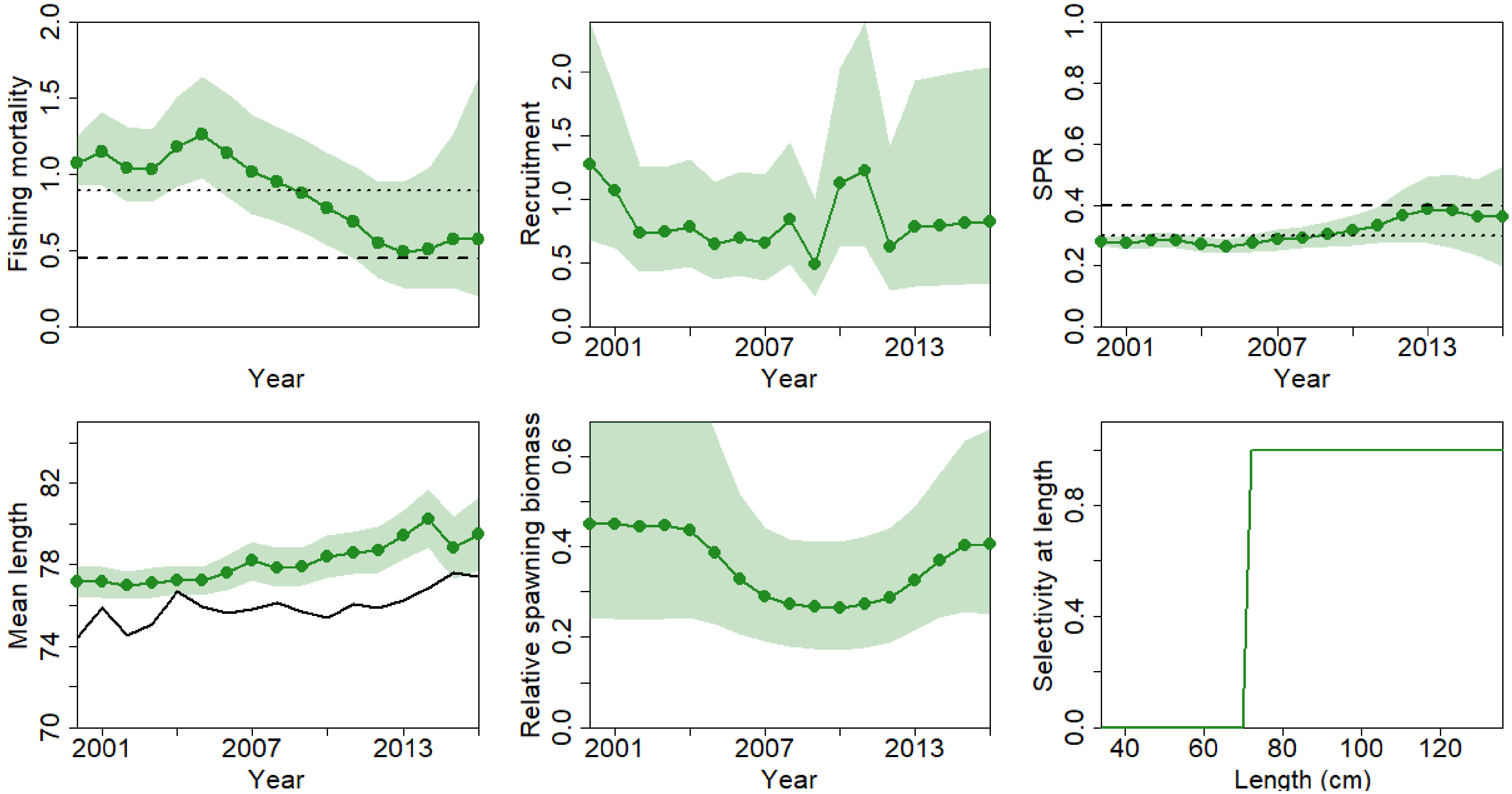
Generated length composition data, labeled by years 1-20.

Una vez establecidos los parámetros y la data, se corre el modelo;

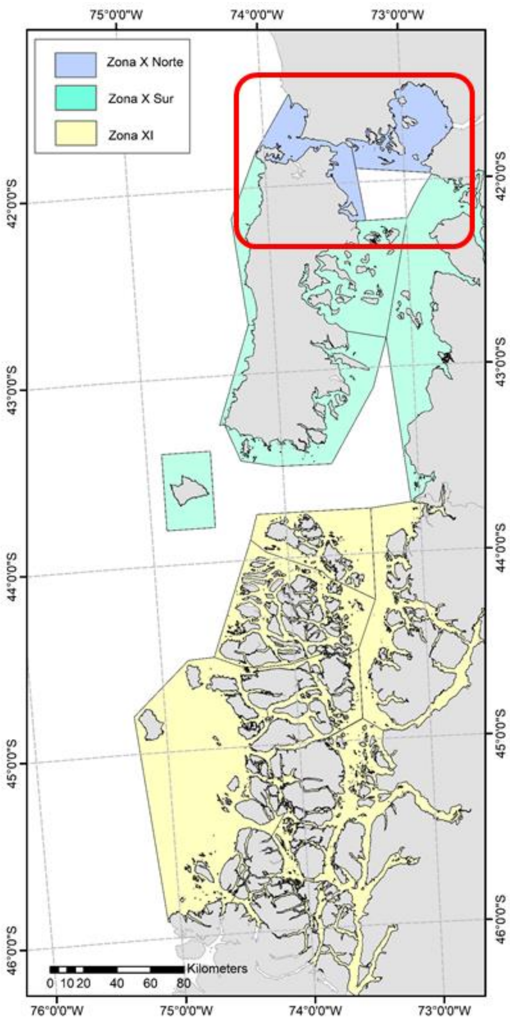
```
res <- run_LIME(modpath=NULL,
                input=inputs,
                data_avail="LC")
```

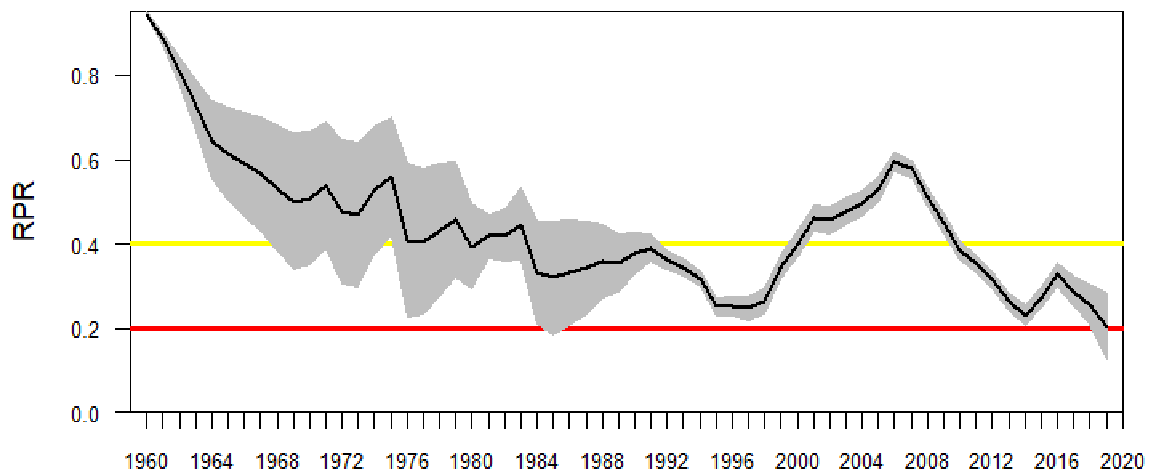

1
6
11
16
2
7
12
17
3
8
13
4
9
14
5
10
15
Proportion
0.10
0.05
0.00
30
60
90
120
Length bin (cm)
Model
LBSPR
LIME

Salidas de LIME: “F", "Rec", "SPR", "ML", "SB", "Selex"



Comparación con el nivel de reducción de la biomasa desovante actual respecto a la biomasa desovante virginal Erizo X Región





REFLEXIONES FINALES

No es pertinente comparar este tipo de modelos en función de sus outputs.

Como es el desempeño de los modelos con respecto a diferentes condiciones de la población o de la dinámica, por ejemplo;

- Rasgos de HV
- Estado e explotación
- Propiedades de los datos

El desempeño de los modelos debe ser evaluado en función del sesgo frente a las condiciones anteriormente descritas (Modelo Operativo).

Fronteras en data poor models…

ICES Journal of Marine Science

ICES CIEM

ICES Journal of Marine Science (2019), doi:10.1093/icesjms/fsz212

Performance evaluation of data-limited, length-based stock assessment methods

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Chong, L., Mildenberger, T. K., Rudd, M. B., Taylor, M. H., Cope, J. M., Branch, T. A., Wolff, M., and Stäbler, M. Performance evaluation of data-limited, length-based stock assessment methods. – ICES Journal of Marine Science, doi:10.1093/icesjms/fsz212.

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Performance evaluation of data-limited, length-based methods is instrumental in determining and quantifying their accuracy under various scenarios and in providing guidance about model applicability and limitations. We conducted a simulation–estimation analysis to compare the performance of four length-based stock assessment methods: length-based Thompson and Bell (TB), length-based spawning potential ratio (LBSPR), length-based integrated mixed effects (LIME), and length-based risk analysis (LBRA), under varying life history, exploitation status, and recruitment error scenarios. Across all scenarios, TB and LBSPR were the most consistent and accurate assessment methods. LBRA is highly biased, but precautionary, and LIME is more suitable for assessments with time-series longer than a year. All methods have difficulties when assessing short-lived species. The methods are less accurate in estimating the degree of recruitment overfishing when the stocks are severely overexploited, and inconsistent in determining growth overfishing when the stocks are underexploited. Increased recruitment error reduces precision but can decrease bias in estimations. This study highlights the importance of quantifying the accuracy of stock assessment methods and testing methods under different scenarios to determine their strengths and weaknesses and provides guidance on which methods to employ in various situations.

Keywords: data-limited fishery, individual-based model, length-based assessment, MSY, simulation–estimation analysis, spawning potential ratio

Introduction

Fisheries are considered data-limited if there are insufficient data to conduct a comprehensive quantitative, model-based stock assessment to estimate time-series of biomass and fishing mortality relative to their reference points (Dowling *et al.*, 2019). Nevertheless, even with limited data, some aspects of stock status can be inferred. Data-limited assessment methods are increasingly used for management purposes to report on the regional status of fisheries across many stocks and to assess the status of individual data-limited stocks as inputs to management decisions (Dowling *et al.*, 2015, 2019; Chrysafi and Kuparinen, 2016). In data-limited fisheries, length-frequency data from commercial catches are often the primary data type collected because they are relatively economical and easy to collect (Pilling *et al.*, 2008; Hordyk *et al.*, 2015a; Mildenberger *et al.*, 2017). As a result, numerous length-based methodologies have been developed. Prominent methods

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Blood from a stone: Performance of catch-only methods in estimating stock biomass status

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ABSTRACT

Demand for data-limited stock assessment methods is increasing, and new methods are being developed rapidly. One class of these methods requires only catch time series and, in some cases, information about life history or fishery characteristics, to estimate stock status. These catch-only methods (COMs) range from statistical models trained on data-rich stocks to mechanistic population models that make assumptions about changes in fishing effort. We review 11 COMs, comparing performance through application to data-rich stocks and simulated fisheries. The catch-only methods evaluated here produce imprecise and biased estimates of B/B_{MSY}, especially for stocks that are lightly exploited. They were also generally poor classifiers of stock status. While no method performed best across all stocks, ensembles of multiple COMs generally performed better than individual COMs. We advocate for testing new COMs using this common platform. We also caution that performance in estimating stock status is not sufficient for gauging the usefulness of COMs in managing fisheries. Greater use of management strategy evaluation is needed before COMs can be considered a reliable tool for management.

1. Introduction

While many stocks in developed parts of the world have comprehensive stock assessments that take into account factors such as life history, age, and abundance trends (Ricard et al., 2012), the majority of global stocks remain unassessed (Costello et al., 2012). The dearth of formal assessments is due to several factors, including a lack of resources for data collection and evaluation. Although this problem may be more prevalent in developing regions and regions with high species diversity, it is also an issue in developed countries for stocks with small population size or low economic value (Neubauer et al., 2018; Thorson and Cope, 2015). Changes to national and international fisheries legislation have required assessment of many stocks not previously assessed (e.g., the reauthorization of the Magnuson–Stevens Fishery Conservation and Management Act in the U.S. in 2006 and the reform of the Common Fisheries Policy in the E.U. in 2013). More broadly, international commitments to the UN Sustainable Development Goals (e.g., Goal 14 requires stocks to be restored to MSY-levels), implies a need to understand the status of more of the world's stocks. In the U.S., Europe, and Australia, where many stocks have time series of catch (i.e., landings plus discards), many new methods for assessing the "catch-only" family of data-limited fisheries have been developed and adopted (Anderson et al., 2017; GFCM, 2017; Newman et al., 2015; Zhou et al., 2016).

Catch-only methods (COMs) are data-limited stock assessment methods that rely primarily on time series of catch or landings to estimate stock biomass status (e.g., B/B_{MSY} or depletion) and other common fisheries reference points and quantities. Some catch-only

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REFLEXIONES FINALES

Visualizar la intensidad de asesoría del DER en relación a estas metodologías.

Implementar PBR basados en modelos del Tier 3.

Gracias.

LIME is an integrated, age-structured model which requires, as input, biological information such as growth, natural mortality, and maturity, and, at minimum, 1 year of length composition data. LIME estimates, as fixed effects, annual fishing mortality rates F, S_{50}, and S_{95}, the recruitment standard deviation, and a Dirichlet-multinomial parameter governing the relationship between the nominal and effective sample size of length measurements. LIME has most of the same assumptions as LBSPR, but LIME does not assume equilibrium conditions when recruitments can be estimated (i.e. more than 1 year of length data). LIME extends length-based methods by deriving time-varying recruitment deviations (Rudd and Thorson, 2018) using automatic differentiation and Laplace approximations (TMB) (Kristensen et al., 2015) to calculate the marginal likelihood for the random effect on recruitment. Using the assumed biological information, recruitment deviates, estimated F, and estimated selectivity, LIME calculates the predicted abundance-at-age over time.