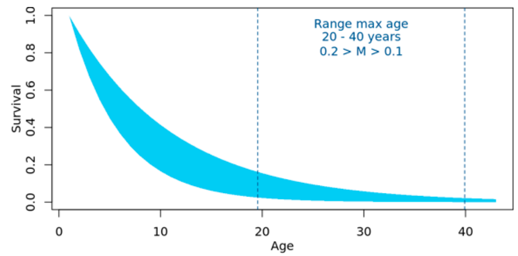
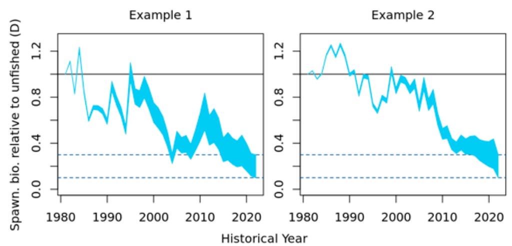
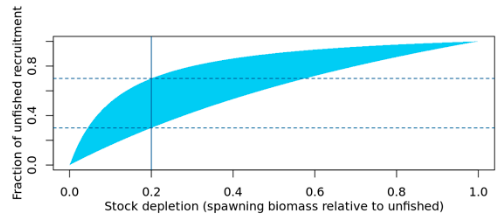
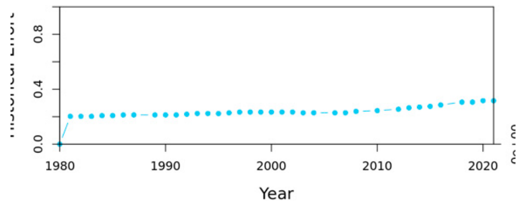
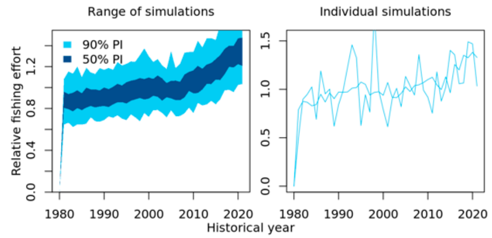
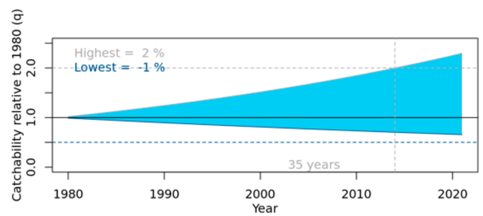
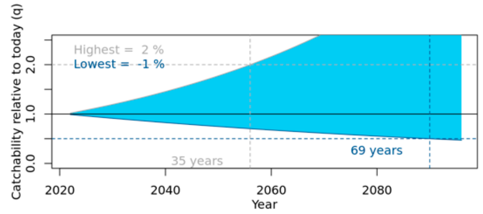
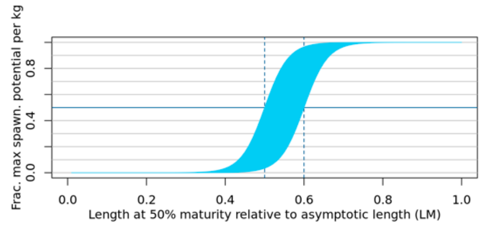
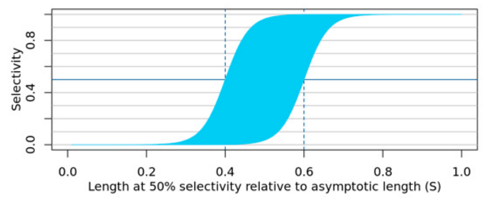
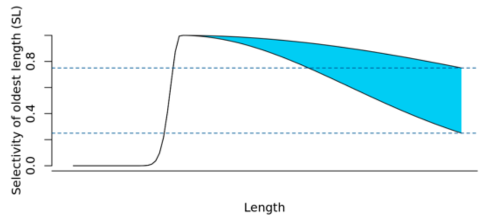
Supplementary Material 1. Table S1: Data input to MERA for *Plectropomus leopardus*

No	MERA Questionnaires	Parameter Input	MERA Description	Justification
		Characteristic of Fisheries		
1	Fishery description	Name: Coral Leopard Grouper Species: *Plectropomus leopardus* Location: Saleh Bay Agency: FIP2B-NTB Fishery start-end: 1980-2022 Author: FIP2B	N/A	N/A
2	Longevity or lifespan	Moderately long-lived (20 < maximum age < 40)	This is a critical input determining stock productivity. The parameter M is the instantaneous natural mortality rate. For a review of data-limited methods of estimating M see Kenchington (2014).	*P. leopardus* is considered as a moderately long-lived species with maximum age at approximately 40 years) Agustina et al. [1]; Ferreira [2]; Russ et al. 1998[3]) 
3	Stock depletion	• Moderately depleted (0.15 < D < 0.3) • Healthy (0.3 < D < 0.5)	Depletion (D), refers to the current spawning stock biomass relative to the unfished level. Since depletion is a data-rich quantity it may not be readily quantified and it may be necessary to specify a wide range of uncertainty for this input to identify MPs that are suitably robust.	Specific information on the current level of depletion for *P. leopardus* in Saleh Bay is not available from previous studies. We used approximation using Hoshino et al. [4] combined with Goethel's et al. [5] models to estimate the current depletion rate at 0.32 (also defined in the fishery data matrix).

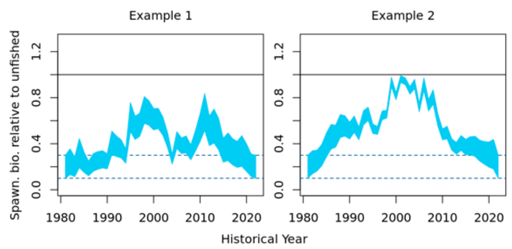
No	MERA Questionnaires	Parameter Input	MERA Description	Justification
				
4	Resilience	Moderate resilience (0.5 < steepness < 0.7)	This question controls recruitment compensation - the extent to which recruitment is reduced from unfished levels (R0) as the spawning stock becomes increasingly depleted below unfished levels (SSB0). Resilience is expressed in terms of steepness (h), which is the fraction of unfished recruitment at 1/5 of unfished spawning biomass. For a useful review of compensatory density dependence in fish populations see Rose et al. (2001).	No specific information of resilience of *P. leopardus* in Saleh Bay. For this parameter we used the study from. Froese et al. [6]: Resilience is medium with a minimum population doubling time 1.4 - 4.4 years (as published in the Fishbase.se). We set the resilience at moderate level. 
5	Historical effort pattern		If more than one effort time series is specified, historical fishing will be simulated by sampling all series with equal probability. This question specifies the possible range of mean trends, users will have an opportunity to adjust the extent of inter-annual variability and changes in fishing efficiency (catchability).	We used data from the national fisheries statistics (*https://satudata.kkp. go.id) at provincial level to estimate the historical effort pattern from 1980 to 2022.*

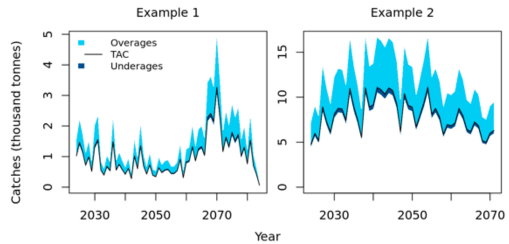
No	MERA Questionnaires	Parameter Input	MERA Description	Justification
				
6	Inter-annual variability in historical effort	Variable (maximum IAC between 20% to 50%)	The extent of interannual variability in historical exploitation rates around the mean trend(s) specified in Fishery Question No.5.	Using the same national fisheries statistics data (*https://satudata.kkp. go.id) at provincial level from 1980-2022, we set the inter-annual variability of historical effort between 20-50%.* 
7	Historical fishing efficiency changes	Increasing by 1-2% pa (doubles every 35-70 years)	The annual percentage increase or decrease in historical fishing efficiency. In targeted fisheries gear efficiency may improve over time given technological improvements in the gear, changes in fishing behavior, fish distribution and information sharing among fishers, among other things. Conversely, non-target or bycatch species may be subject to declining fishing efficiency due to regulations or avoidance behaviors. The catchability (q) is the fraction of available fish caught per unit of effort. For example, a 2% per annum increase in fishing efficiency means that after 35 years twice as	Historical fishing efficiency is estimated between 1-2% based on historical understanding that technological advancement in fishing operations is relatively low in this type of fishery. 

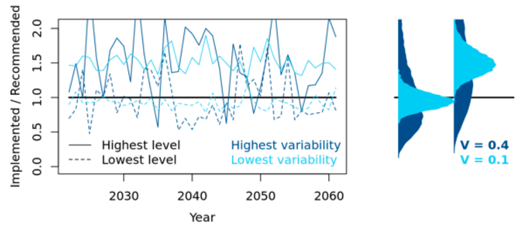
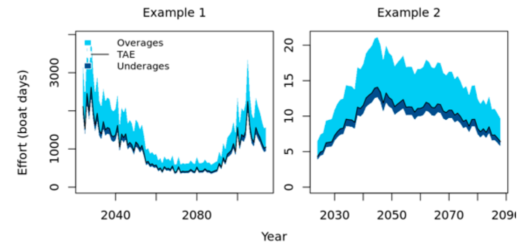
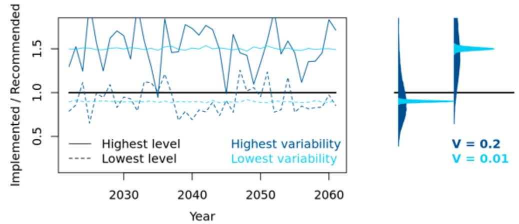
No	MERA Questionnaires	Parameter Input	MERA Description	Justification
			many fish will be caught for the same effort as today.	
8	Future fishing efficiency changes	Stable -1 to 1% per annum (doubled every 70 years) Increasing by 1-2% per annum (doubles every 35-70 years)	The annual percentage increase or decrease in future fishing efficiency. In targeted fisheries gear efficiency may improve over time given technological improvements in the gear, changes in fishing behavior, fish distribution and information sharing among fishers, among other things. Conversely, non-target or bycatch species may be subject to declining fishing efficiency due to regulations or avoidance behaviors. The catchability (q) is the fraction of available fish caught per unit of effort. For example, a 2% per annum increase in fishing efficiency means that after 35 years twice as many fish will be caught for the same effort as today.	Future fishing efficiency is estimated between -1 to 2% based on assumption that future technological advancement in fishing operations is relatively low or stable in this type of fishery. However, changes in market value and increase of demand in the future possibly increase fishing efficiency. 
9	Length at maturity	Small (0.5 < LM < 0.6)	Size a maturity relative to asymptotic length (LM). Note 1: 'maturity' as used by this model (and most fish population dynamics models) is not really whether a fish has fully developed gonads, but rather the fraction of maximum spawning potential per weight. For example, some fishes mature early, but at small sizes they spawn infrequently and their recruits have poor survival (low spawning fraction). Note 2: asymptotic length is not the maximum length observed but rather the mean expected size of fish at their maximum age under unfished conditions	There is a large variation of Lm and L∞ for *P. leopardus* (e.g., Bawole et al. [7]. According to Effendi et al. [8], the Lm and L∞ for this species in Saleh Bay is estimated at 38.3cm and 71.9cm respectively. Hence, we set the ratio of Lm to L∞ at Small category (0.5<LM<0.6). 

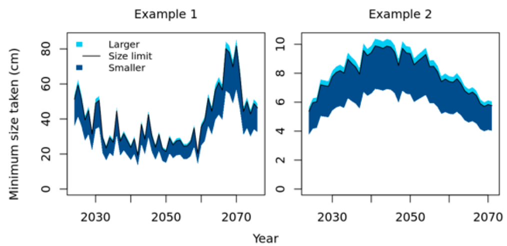
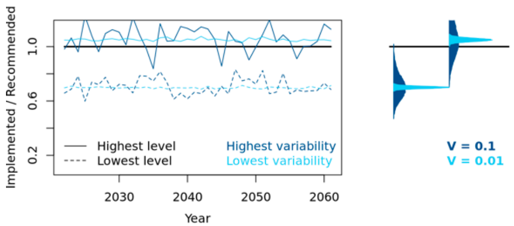
No	MERA Questionnaires	Parameter Input	MERA Description	Justification
10	Selectivity of small fish	Half asymptotic length (0.4 < S < 0.6)	Fishing gear selectivity relative to asymptotic length (S) (ascending limb selectivity). For example, if 50% of 40cm fish are caught and maximum length is 100cm, S = 0.4. The UN FAO provides an introduction to gear selectivity and how it may be quantified.	With the assumption that selectivity is Lc/L∞, according to Agustina et al.[1], the selectivity is around 0.4 where Lc=29.82 and L∞=71.9. Hence, we set selectivity at half asymptotic length (between 0.4 and 0.6) 
11	Selectivity of large fish	Dome-shaped selectivity (0.25 < SL < 0.75)	Fishing gear selectivity relative to asymptotic length (S) (ascending limb selectivity). For example, if 50% of 40cm fish are caught and maximum length is 100cm, S = 0.4. The UN FAO provides an introduction to gear selectivity and how it may be quantified.	Same with Question No. 10 
12	Discard rate	Low (DR<1%)	Discard rate (DR) is the fraction of fish that discarded both dead and alive The US National Marine Fisheries Service has a general guide to Understanding Fish Bycatch Discard and Escapee Mortality. and one of the authors of that guide, Michael Davis also has a useful article: Key principles for understanding fish bycatch discard mortality.	Based on field observation that discarding is not a common practice from small-scale fishers in the study area.
13	Post release mortality rate	Moderate (25% < PRM < 50%)	The post-release mortality rate (PRM) is the fraction of discarded fish that die after release.	Post-release mortality is vary based on the species and depth of where the fish was

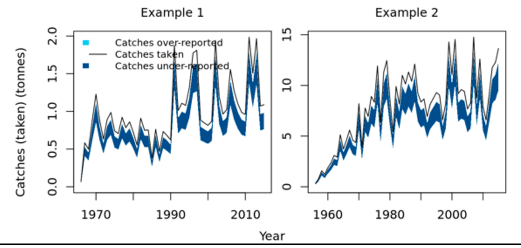
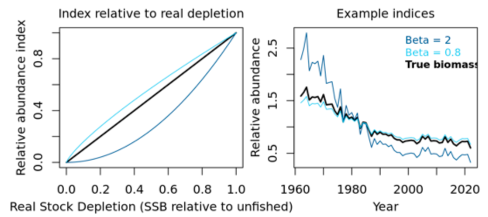
No	MERA Questionnaires	Parameter Input	MERA Description	Justification
		Moderate - high (50% < PRM < 75%)	The US National Marine Fisheries Service have a general guide to Understanding Fish Bycatch Discard and Escapee Mortality. and one of the authors of that guide, Michael Davis also has a useful article: Key principles for understanding fish bycatch discard mortality.	originally caught. It is ranging from >77% for fish caught deeper than 44 meter and 0-14% if caught shallower than 44 meter (Wilson and Burns 1996 [9]). Another study from Overton et al. [10] suggests mortality rate ranging from 6.1 to 12.3%.
14	Recruitment variability	Low (max IAC of between 20% and 60%)	The interannual variability in recruitment is expressed here as the maximum inter-annual change. Recruitment is expected to change among years in response to spawning biomass levels. Additional variability may be driven by many factors including varying ocean conditions, amount of spawning habitat, food availability and predation. Recruitment variation is commonly described by the coefficient of variation in log-normal recruitment deviations (sigma R). An approximate rule of thumb is that 95% of recruitments fall in a range that is twice the sigma R. So given a sigma R of 10%, 95% of recruitments will fall within an interannual change of 20% of the mean recruitment predicted from spawning biomass.	There is no information to estimate recruitment variability for this species in Saleh Bay. We assumed that that recruitment is highly influenced by abiotic variability. Given the relatively low annual abiotic variability in Saleh Bay, we set the recruitment variability at low level with annual variability between 20-60%. 
15	Size of an existing MPA (no take area)	Small (<5%)	The size of a existing spatial closure (e.g. Marine Protected Area, MPA). The size A, is the % of habitat that is protected (the same fraction closed is applied to the habitats of all life stages, for example spawning and rearing grounds).	Total of MPA no take area is 45.4 km^2; or less than 5% to the area of Saleh Bay (2,087 km^2)
16	Spatial mixing (movement) in/out of existing MPA	High (10% < P < 20%)	Stock mixing in/out of existing spatial closure. The degree of the spatial mixing of the fish stock is represented as the probability (P) of a	Adult *P. leopardus* only move locally around its habitats, including their spawning aggregation sites. This species is only active during daytime and hiding under ledges during night time

No	MERA Questionnaires	Parameter Input	MERA Description	Justification
			fish leaving the spatial closure (i.e., the marine protected area, MPA) between years	https://www.fishbase.se/summary /4826). Given the no-take area in the MPAs is still within the same reef system, we assume that the spatial mixing is moderate to high.
17	Size of a future potential MPA	Small (<5%)	The size of a potential future spatial closure (Marine Protected Area, MPA). The size A, is the % of habitat that is protected (the same fraction closed is applied to the habitats of all life stages, for example spawning and rearing grounds).	New MPA (Pulau Lipan and Pulau Rakit MPA) is currently being established in Saleh Bay but the total no-take area remains small (<5%) relative to the size of Saleh Bay.
18	Spatial mixing (movement) in/out of future potential MPA	High (10% < P < 20%)	Stock mixing in/out of a future spatial closure. The degree of the spatial mixing of the fish stock is represented as the probability (P) of a fish leaving the closed area (i.e., the marine protected area, MPA) between years.	Same with Question No. 16
19	Initial stock depletion	• Very low (0.1 < D1 < 0.15) • Low (0.15 < D1 < 0.3)	Initial depletion of the stock relative to asymptotic unfished levels (D1: spawning stock biomass in year 1 relative to equilibrium unfished conditions). Many fisheries undertake large fluctuations in productivity. In some of these cases, a fishery may have begun at a time when the stock was naturally low. This question provides an opportunity to specify this initial depletion. The default however is that the stock was at asymptotic unfished levels in the first year of the fishery. For further information see Carruthers et al. (2014) and Punt et al (2011)	Given no information on initial stock depletion is available. Low and very low initial stock depletion was selected based on expert judgment, assuming low to very low stock depletion before the fisheries exist. 
	Management (Types of fishery management that are applicable)			
1	Types of fishery management that are possible	All options are selected	Here users can indicate which MPs are feasible given the management options that are available.	Although the current policy in Saleh Bay is implementing size limit and MPA as management procedures (MPs), we keep the

No	MERA Questionnaires	Parameter Input	MERA Description	Justification
			Management procedures can provide management advice in terms of: - Total Allowable Catch (TAC, e.g., 20,000 metric tonnes). - Total Allowable Effort (TAE, e.g., 800 trap days per year). - Size limits (e.g., minimum size of 45cm). - Time-area closures (e.g., a permanent marine protected area or seasonal closure).	option for TAC and TAC-based MPs are open for evaluation.
2	TAC offset: consistent overages/underages	• Taken exactly (95% - 105% of recommended) • Slight overages (100% - 110% of recommended) • Overages (110% - 150% of recommended)	What is the possible extent to which fishing operations may exceed (overages) or fall short (underages) of the specified Total Allowable Catch (TAC)? For example, given a TAC of 1000 tonnes a 10% offset (overage) would on average lead to 1100 tonnes of fish taken.	There is no TAC regulation is currently implemented in Saleh Bay. However, when the compliance monitoring system to TAC is available, TAC offset is expected between 95-120% when implemented, with the assumption that TAC might set lower than mean annual catch. 
3	TAC implementation variability	• Variable (10% < V < 20%) • Highly variable (20% < V < 40%)	In the previous question user specified the range of the possible TAC offset (mean overage or underage). In this question user add the variability (V) in the implementation of TACs among years. For example, if on average there is no TAC offset, a V of 10% leads to annual	We use the same justification as Question No. 2 with variability assumed between 10-40%.

No	MERA Questionnaires	Parameter Input	MERA Description	Justification
			overages/underages within 20% of the annual TAC recommendation (the black line in the figure opposite) for 95% of cases. The colored lines show the minimum and maximum variability superimposed on the lowest (dashed line) and highest (solid line) levels of overages/underages specified in the previous question.	
4	TAE offset: consistent overages/underages	Overages (110% - 150% of recommended) "	What is the possible extent to which fishing operations may exceed (overages) or fall short (underages) of the specified Total Allowable Effort (TAE)? For example, given a TAE of 2000 boat-days of fishing a 10% overage would on average lead to 2200 boat days of effort.	TAE regulation is also not implemented in Saleh Bay. However, since there is no effort monitoring system in place, TAE offset is assumed between 90-120% when implemented. 
5	TAE implementation variability	Variable (10% < V < 20%)	In the previous question user specified the range of possible TAE offset (mean overages/underages). In this question user add the variability (V) in the implementation of TAEs among years. For example, if on average there is no TAE offset, a V of 20% leads to annual TAE overages/underages within 40% of the annual TAE recommendation (the black line in the figure opposite) for 95% of cases. The colored lines show the minimum and maximum variability superimposed on the lowest (dashed line) and highest (solid line)	We use the same justification as Question No. 4, with variability is assumed between 5-20%. 

No	MERA Questionnaires	Parameter Input	MERA Description	Justification
			levels of overages/underages specified in the previous question.	
6	Size limit offset: catching consistently smaller/larger than min. size	Smaller (70% - 90% of recommended)	What is the possible extent to which fishing operations may exceed (catch larger) or fall short (catch smaller) fish than the specified minimum size limit? For example, given a size limit of 20cm (e.g. escape hole size of a trap), a value of 20% would lead to a mean minimum size in the catch of 24cm.	According to Effendi et al. [8] *Lc* of *P. leopardus* is 33 cm. With the assumption size limit is set at Lm (38.8 cm), the size limit offset is estimated at 15%. 
7	Size limit implementation variability	Overages (110% - 150% of recommended) "	In the previous question user specified the range of possible mean violations of a minimum size limit. In this question user add variability (V) in size limit implementation among years. For example, a size limit of 90cm is exceeded by an average of 10cm, a value of 5% leads to minimum catch sizes of between 90cm and 110cm (the black line in the figure opposite) for 95% of cases. The colored lines show the minimum and maximum variability superimposed on the lowest (dashed line) and highest (solid line) offset in size limit specified in the previous question.	With the assumption of relatively low variability in catch size within the same fishing effort, we set the variability of between 1-10%. 
		Data Quality		
1	Load fishery data (optional)	Load available data (.csv .xlsx .rda)	Users have the option of loading fishery data to unlock various MERA features When formatted into a DLMtool/MSEtool csv data file, fishery data can be used to:	Fisheries data matrix is provided (Appendix 2)

No	MERA Questionnaires	Parameter Input	MERA Description	Justification
			- condition operating models - determine feasible MPs (Management Planning mode) - assess the fishery status (Status Determination mode) - test for exceptional circumstances (Management Performance mode).	
2	Catch reporting bias	Under-reporting (10% - 30%) Slight under-reporting (0% - 10%)	Catch reporting bias includes a chronic misreporting of the catch over time. In some data-limited fisheries, incomplete monitoring of fishing operations may lead to under-reporting (and to a lesser extent over-reporting) of annual catches.	With the limited scope of catch monitoring, and fishers are rarely land their catch in fishing ports, the catch reporting is assumed has bias between 0-30%. 
3	Hyperstability in indices	Hyperdepletion (1.25 < Beta < 2) Proportional (0.8 < Beta < 1.25)	Is the primary index of relative abundance proportional to real biomass? Indices of relative abundance derived from fishery catch-per-unit effort (CPUE) may decline faster than real abundance (hyperdepletion) in cases where, for example, the species is being avoided or there has been attrition of high-density sub-population structure during early commercial fishing. Conversely CPUE data may respond slower than real biomass changes (hyperstability) if the species is being targeted, there is range contraction of fishing toward high density areas	There is no specific information on hyperstability indices for *P. leopardus*. Based on the *P. leopardus* characteristics which mostly solitary, we assumed that this species has proportional (0.8<Beta<1.25) to hyperdepletion (1.25 < Beta < 2) of hyperstability index. 

No	MERA Questionnaires	Parameter Input	MERA Description	Justification
			as the stock declines or the population naturally forms aggregations. For example, purse-seine fisheries are often strongly hyperstable since the fish per aggregation may remain high even at low stock sizes. It may be generally assumed that a well-designed fishery-independent survey is proportional to abundance but there are notable exceptions.	
4	Overall data quality	Good quality data	Perfect Information: an unrealistic and idealized observation model for testing the theoretical performance of MPs. Good quality: annual catches and abundance indices are observed with low error (<20% CV) and length/age composition data are numerous (~100 independent observations per year). Data moderate: annual catches and abundance indices are observed with greater error (<30% CV) and length/age composition data are fewer (~40 independent samples per year). Data poor: annual catches and abundance indices are imprecisely observed (<50% CV) and length/age composition data are sparse (~15 independent samples per year).	Annual catches and abundance indices are observed with a relatively low error (<20% CV) and length/age composition data are numerous (~100 independent observations per year).

Supplementary Material 2. Table S2: Fishery data matrix for operational model conditioning (general information and biology); CV = coefficient of annual variation.

Name	Data
Name	Kerapu sunu
Common Name	Coral leopard grouper
Species	*Plectropomus leopardus*
Region	Saleh Bay
Last Historical Year	2021

Biology	
Maximum age	26
M	0.16
CV M	0.01
Von Bertalanffy Linf parameter	71.94
CV von B. Linf parameter	0.01
Von Bertalanffy K parameter	0.12
CV von B. K parameter	0.01
Von Bertalanffy t0 parameter	-1.17
CV von B. t0 parameter	-0.29
Length-weight parameter a	0.0118
CV Length-weight parameter a	no data
Length-weight parameter b	3.06
CV Length-weight parameter b	no data
Steepness	no data
CV Steepness	no data
sigmaR	no data
CV sigmaR	no data
Length at 50% maturity	38.83
CV Length at 50% maturity	0.01
Length at 95% maturity	41.8
CV of length-at-age	0.01

Selectivity	
Length at first capture	34.6
CV Length at first capture	0.01
Length at full selection	no data
CV Length at full selection	no data
Vulnerability at asymptotic length	no data

Supplementary Material 2. Table S2 (continued): Fishery data matrix for operational model conditioning (selectivity, time series data, catch-at-length, and depletion rate); CV = coefficient of annual variation.

Time-Series

Year	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Catch (kg)	3773.13	3347.7	3766.35	3224.11	4089.62	4401.09	4442.51	3797.56	5652.77	3992.3	5536.305	3231.499	5620.362
CV Catch	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Effort	no data												
CV Effort	no data												
Abundance index	no data												
CV Abundance index	no data												
Spawning Abundance index	no data												
CV Spawning Abundance index	no data												
Vulnerable Abundance index	3.8	4.2	2.8	2.7	2.9	2.5	3.1	2.5	2.4	2.2	6.4	5.5	6.1
CV Vulnerable Abundance index	no data												

Catch-at-Length

Vuln CAL

CAL_bins	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60	62	64	66	68
CAL_2016	1	2	12	23	49	87	128	120	107	84	74	38	53	42	30	20	25	16	11	10	6	4	6	1	4
CAL_2017	0	0	0	3	13	27	58	60	73	76	74	78	50	62	36	33	44	24	32	13	13	9	2	5	2
CAL_2018	0	0	0	0	4	12	34	65	82	98	96	112	59	64	36	38	19	21	13	12	5	5	2	2	0
CAL_2019	0	0	1	3	3	18	33	66	81	58	73	69	54	52	33	39	22	23	20	12	12	10	1	1	0
CAL_2020	0	0	0	0	0	5	24	39	42	73	49	44	38	39	25	23	23	25	9	10	9	8	4	1	0
CAL_2021	0	0	0	0	0	3	7	35	53	44	46	46	39	21	29	16	18	15	13	10	10	10	5	2	0

Reference

Current stock depletion	0.32

Supplementary Material 3. Table S3: The 20 MERA's default management procedures (MPs) simulated in this study. Descriptions of the default MPs are from DLM Tool Documentation 6.0.6 by T. Carruthers, Q Huynh, and A. Hordyk (https://dlmtool.openmse.com/reference/index.html).

MP	Description	References
Total Allowable Catch (TAC)		
DBSRA (Depletion-Based Stock Reduction Analysis)	**Depletion-Based Stock Reduction Analysis** (DB-SRA); a method for setting a catch limit and management reference points for data-limited fisheries with known catches from the start of exploitation. By back-constructing the stock to meet a user-specified level of stock depletion, BMSY/B_0, M, and FMSY/M are utilized to calculate B_0 and hence the catch limit. TAC is calculated at the assumed MSY harvest rate multiplied by the estimated current abundance (estimated B_0 x Depletion)	Carruthers et al. [11]
DBSRA_40 (Depletion-Based Stock Reduction Analysis 40)	Similar to DBSRA, but assumes 40% current depletion (i.e., $B_{current}/B_0 = 0.4$), which is the most optimistic position for a stock (i.e., extremely close to BMSY/B_0 for many stocks).	Carruthers et al. [11]
DBSRA4010 (Depletion-Based Stock Reduction Analysis 4010)	DBSRA in conjunction with the 40-10 rule, which progressively reduces the TAC from 0.4 to zero at 10% unfished biomass depletion.	Carruthers et al. [11]
DCAC (Depletion Corrected Average Catch)	**Depletion Corrected Average Catch** (designed as an MSY proxy) determines a catch limit based on average historical catch while accounting for windfall catch that brought the stock down to its current depletion level (D). Future forecasts do not include depletion. The TAC is fixed and will not be modified in the future. This is an application of the DCAC approach in which a catch limit is determined based on current depletion estimates and catch time series from the start of the fishery, and the TAC is fixed at this level for all future predictions.	MacCall [12]; Harford and Carruthers [13]
DCAC_40 (Depletion Corrected Average Catch 40)	DCAC with the assumption that the current stock biomass is at 40% of the unfished level. The 40 percent depletion assumption may not have much of an impact on DCAC because it already generates TAC recommendations that are somewhat MSY-like.	MacCall [12]; Harford and Carruthers [13]
DD (Delay-Difference Stock Assessment)	**Delay-Difference** Stock Assessment, a simple delay-difference analysis utilizing U_{MSY} (catch rate at MSY) and MSY as leading parameters to estimate the TAC from a time series of catch and relative catch. TAC = U_{MSY} * Current Biomass.	Carruthers et al. [14]; Hilborn and Walters [15]
DD4010 (Delay-Difference Stock Assessment 4010)	DD model with the 40-10 rule imposed over the TAC recommendation, which progressively reduces the TAC from 0.4 to zero at 10% unfished biomass depletion.	Carruthers et al. [14]; Hilborn and Walters [15]

MP	Description	References
MCD (Mean Catch Depletion)	**Mean Catch Depletion**, a simple average catch-depletion MP was added to show how useful an estimate of current stock depletion may be. The TAC is calculated as: TAC=2C_{mean} x D, where C_{mean} is mean historical catch, and D is estimate of current depletion.	T. Carruthers, Q Huynh, and A. Hordyk (https://dlmtool.openmse.com/reference/index.html)
MCD4010 (Mean Catch Depletion 4010)	The MCD model with 40-10 rule imposed over the TAC	T. Carruthers, Q Huynh, and A. Hordyk (https://dlmtool.openmse.com/reference/index.html)
Fratio (F and M ratio)	F_{MSY}/M ratio methods, this method calculated OFL (over fishing limit) using a set ratio of F_{MSY} (fishing mortality at MSY) to M (natural mortality) and the current abundance estimate. The TAC is calculated as: TAC=F_{MSY} x A, where F_{MSY} is derived from $\frac{F_{MSY}}{M}$ M, and A is estimate of current abundance.	Gulland [16]; Martell and Froese [17]; Dick and McCall [18]
HDAAC (Hybrid Depletion Adjusted Average Catch)	**Hybrid Depletion Adjusted Average Catch**: where DCAC (with updated Depletion) divided by B_{MSY}/B_0 (B_{peak}) when below B_{MSY}, and DCAC above B_{MSY}	Harford and Carruthers [13].
IT10 (Iterative Index Target 10%)	**Iterative Index Target** MP (10%), an index target MP in which the TAC is adjusted based on current index levels (mean index over the previous 5 years) in relation to a target level. The TAC is calculated as: $TAC_y = C_{y-1}\ x\ I_\delta$, where C_{y-1} is the catch from the previous year and I_δ is the ratio of the mean index over the past years to a reference index level. Maximum annual change of TAC is set at 10%.	T. Carruthers, Q Huynh, and A. Hordyk (https://dlmtool.openmse.com/reference/index.html)
IT5 (Iterative Index Target 5%)	Similar to IT10 with maximum annual change of TAC is set at 5%.	T. Carruthers, Q Huynh, and A. Hordyk (https://dlmtool.openmse.com/reference/index.html)
Total Allowable Effort (TAE)		
DDe (Effort-based Delay-Difference Stock Assessment)	**Effort-based Delay-Difference** Stock Assessment, a simple delay-difference analysis with U_{MSY} and MSY as leading parameters that calculates E_{MSY} using a time series of catches and a relative abundance index. This DD model solely estimates observation error and does not account for process error (recruitment deviations). It is assumed that knife-edge selectivity occurs at 50% maturity. The method is based on effort and catch estimates. The effort is calculated as the ratio of catch and index. To obtain a comprehensive effort time series, a complete catch and index time series is also required. Missing values are interpolated linearly. A detailed description of the delay-difference model can be found in Chapter 9 of Hilborn and Walters (1992).	Hilborn and Walters [15]

MP	Description	References
DDe75 (Effort-based Delay-Difference Stock Assessment 75%)	A variant of DDe model where the recommended effort is set at 75% of the current effort?	Hilborn and Walters [15]
ITe10 (Index Target Effort-Based 10%)	**Index Target Effort-Based** (10%), an effort-based index target MP where the Effort is modified according to current index levels (mean index over last 5 years) relative to a target level. Maximum annual change of Effort is set at 10%.	T. Carruthers, Q Huynh, and A. Hordyk (https://dlmtool.openmse.com/reference/index.html)
Size limit		
Matlenlim (Size limit at length-at-maturity)	**Matlenlim** - Size limit management procedures, a set of size-selectivity MPs that adjust the retention curve of the fishery. The fishing retention-at-length is set equivalent to the length at 50%, estimated from the size at maturity curve.	Hordyk et al. [19]
Matlenlim2 (Size limit at 110% length-at-maturity)	The matlenlim model where fishing retention-at-length is set slightly higher (110%) than the length-at-maturity.	Hordyk et al. [19]
Spatial closures/Marine Protected Area		
MRnoreal (Spatial closure – no reallocation)	Spatial closure with no reallocation – closes an area (area 1) to fishing and has NO reallocation of fishing effort to other areas (area 2).	T. Carruthers, Q Huynh, and A. Hordyk (https://dlmtool.openmse.com/reference/index.html)
MRreal (Spatial closure – with reallocation)	Spatial closure with reallocation MP is a management procedure that closes an area (area 1) to fishing AND reallocates fishing effort to other areas (area 2).	T. Carruthers, Q Huynh, and A. Hordyk (https://dlmtool.openmse.com/reference/index.html)

Supplementary Material 4. Script S4: R-scripts for custom Management Procedures

```
# SIZE LIMIT MPs
SL_32 <- function(x, Data, ...) {
  Rec <- new('Rec')
  Rec@L5 <- 30
  Rec@LFS <- 32
  Rec
}
class(SL_32) <- 'MP'

SL_MP <- function(SL=25) {
  out <- function(x, Data, ...) {
    Rec <- new('Rec')
    Rec@L5 <- SL*.95
    Rec@LFS <- SL
    Rec
  }
  class(out) <- 'MP'
  out
}

SL_25 <- SL_MP()
SL_28 <- SL_MP(28)
SL_30 <- SL_MP(30)
SL_32 <- SL_MP(32)
SL_34 <- SL_MP(34)
SL_36 <- SL_MP(36)
SL_38 <- SL_MP(38)
SL_40 <- SL_MP(40)

# SEASONAL CLOSURE MPs
SC_2 <- function(x, Data, ...) {
  Rec <- new('Rec')
  Rec@Effort <- 1-2/12
  Rec
}
class(SC_2) <- 'MP'

SC_3 <- function(x, Data, ...) {
  Rec <- new('Rec')
  Rec@Effort <- 1-3/12
  Rec
}
class(SC_3) <- 'MP'

SC_4 <- function(x, Data, ...) {
  Rec <- new('Rec')
  Rec@Effort <- 1-4/12
  Rec
}
class(SC_4) <- 'MP'
```

```
# TAC MPs
# Index-Tracking TAC
Index_10_TAC <- function(x, Data, ...) {

  # Most recent catch
  LastCatch <- Data@Cat[x, ncol(Data@Cat)]

  nyears <- length(Data@Year)

  # Reference Index
  # mean index over the last X years
  Ref_Yrs <- (nyears-4):nyears
  Ref_Ind <- mean(Data@VInd[x,Ref_Yrs])

  # Recent Index - Index in most recent year
  Recent_Ind <- Data@VInd[x,nyears]

  # HCR
  # Default - keep TAC at the most recent catch
  TAC <- LastCatch
  if (Recent_Ind < 0.9*Ref_Ind) {
    # Index is less than 90% Reference Index
    TAC <- LastCatch * 0.9
  }
  if (Recent_Ind > 1.1*Ref_Ind) {
    # Index is greater than 110% Reference Index
    TAC <- LastCatch * 1.1
  }

  Rec <- new('Rec')
  Rec@TAC <- TAC
  Rec
}
class(Index_10_TAC) <- 'MP'


# Index-Tracking TAC
Index_15_TAC <- function(x, Data, ...) {

  # Most recent catch
  LastCatch <- Data@Cat[x, ncol(Data@Cat)]

  nyears <- length(Data@Year)

  # Reference Index
  # mean index over the last X years
  Ref_Yrs <- (nyears-4):nyears
  Ref_Ind <- mean(Data@VInd[x,Ref_Yrs])

  # Recent Index - Index in most recent year
```

```
  Recent_Ind <- Data@VInd[x,nyears]

  # HCR
  # Default - keep TAC at the most recent catch
  TAC <- LastCatch
  if (Recent_Ind < 0.85*Ref_Ind) {
    # Index is less than 90% Reference Index
    TAC <- LastCatch * 0.85
  }
  if (Recent_Ind > 1.15*Ref_Ind) {
    # Index is greater than 110% Reference Index
    TAC <- LastCatch * 1.15
  }

  Rec <- new('Rec')
  Rec@TAC <- TAC
  Rec
}
class(Index_15_TAC) <- 'MP'
```

Index-Tracking TAC

```
Index_20_TAC <- function(x, Data, ...) {

  # Most recent catch
  LastCatch <- Data@Cat[x, ncol(Data@Cat)]

  nyears <- length(Data@Year)

  # Reference Index
  # mean index over the last X years
  Ref_Yrs <- (nyears-4):nyears
  Ref_Ind <- mean(Data@VInd[x,Ref_Yrs])

  # Recent Index - Index in most recent year
  Recent_Ind <- Data@VInd[x,nyears]

  # HCR
  # Default - keep TAC at the most recent catch
  TAC <- LastCatch
  if (Recent_Ind < 0.8*Ref_Ind) {
    # Index is less than 90% Reference Index
    TAC <- LastCatch * 0.8
  }
  if (Recent_Ind > 1.2*Ref_Ind) {
    # Index is greater than 110% Reference Index
    TAC <- LastCatch * 1.2
  }

  Rec <- new('Rec')
  Rec@TAC <- TAC
  Rec
}
class(Index_20_TAC) <- 'MP'
```

Index-Tracking TAC

```
Index_25_TAC <- function(x, Data, ...) {

  # Most recent catch
  LastCatch <- Data@Cat[x, ncol(Data@Cat)]

  nyears <- length(Data@Year)

  # Reference Index
  # mean index over the last X years
  Ref_Yrs <- (nyears-4):nyears
  Ref_Ind <- mean(Data@VInd[x,Ref_Yrs])

  # Recent Index - Index in most recent year
  Recent_Ind <- Data@VInd[x,nyears]

  # HCR
  # Default - keep TAC at the most recent catch
  TAC <- LastCatch
  if (Recent_Ind < 0.75*Ref_Ind) {
    # Index is less than 90% Reference Index
    TAC <- LastCatch * 0.75
  }
  if (Recent_Ind > 1.25*Ref_Ind) {
    # Index is greater than 110% Reference Index
    TAC <- LastCatch * 1.25
  }

  Rec <- new('Rec')
  Rec@TAC <- TAC
  Rec
}
class(Index_25_TAC) <- 'MP'
```

TAE MPs

Index-Tracking Effort

```
Index_10_Eff <- function(x, Data, ...) {

  nyears <- length(Data@Year)
  # Reference Index
  # mean index over the last X years
  Ref_Yrs <- (nyears-4):nyears
  Ref_Ind <- mean(Data@VInd[x,Ref_Yrs])

  Recent_Ind <- Data@VInd[x,nyears]

  Last_Effort <- Data@MPeff[x]
  Effort <- Last_Effort
  if (Recent_Ind < 0.9*Ref_Ind) {
    # Index is less than 90% Reference Index
```

```
    Effort <- Last_Effort* 0.9
  }
  if (Recent_Ind > 1.1*Ref_Ind) {
    # Index is greater than 110% Reference Index
    Effort <- Last_Effort *1.1
  }

  Rec <- new('Rec')
  Rec@Effort <- Effort
  Rec
}
class(Index_10_Eff) <- 'MP'
```

Index-Tracking Effort

```
Index_15_Eff <- function(x, Data, ...) {

  nyears <- length(Data@Year)
  # Reference Index
  # mean index over the last X years
  Ref_Yrs <- (nyears-4):nyears
  Ref_Ind <- mean(Data@VInd[x,Ref_Yrs])

  Recent_Ind <- Data@VInd[x,nyears]

  Last_Effort <- Data@MPeff[x]
  Effort <- Last_Effort
  if (Recent_Ind < 0.85*Ref_Ind) {
    # Index is less than 85% Reference Index
    Effort <- Last_Effort* 0.85
  }
  if (Recent_Ind > 1.15*Ref_Ind) {
    # Index is greater than 115% Reference Index
    Effort <- Last_Effort *1.15
  }

  Rec <- new('Rec')
  Rec@Effort <- Effort
  Rec
}
class(Index_15_Eff) <- 'MP'
```

Index-Tracking Effort

```
Index_20_Eff <- function(x, Data, ...) {

  nyears <- length(Data@Year)
  # Reference Index
  # mean index over the last X years
  Ref_Yrs <- (nyears-4):nyears
  Ref_Ind <- mean(Data@VInd[x,Ref_Yrs])

  Recent_Ind <- Data@VInd[x,nyears]

  Last_Effort <- Data@MPeff[x]
  Effort <- Last_Effort
  if (Recent_Ind < 0.8*Ref_Ind) {
    # Index is less than 80% Reference Index
    Effort <- Last_Effort* 0.8
  }
  if (Recent_Ind > 1.2*Ref_Ind) {
    # Index is greater than 120% Reference Index
    Effort <- Last_Effort *1.2
  }

  Rec <- new('Rec')
  Rec@Effort <- Effort
  Rec
}
class(Index_20_Eff) <- 'MP'
```

Index-Tracking Effort

```
Index_25_Eff <- function(x, Data, ...) {

  nyears <- length(Data@Year)
  # Reference Index
  # mean index over the last X years
  Ref_Yrs <- (nyears-4):nyears
  Ref_Ind <- mean(Data@VInd[x,Ref_Yrs])

  Recent_Ind <- Data@VInd[x,nyears]

  Last_Effort <- Data@MPeff[x]
  Effort <- Last_Effort
  if (Recent_Ind < 0.75*Ref_Ind) {
    # Index is less than 75% Reference Index
    Effort <- Last_Effort* 0.75
  }
  if (Recent_Ind > 1.25*Ref_Ind) {
    # Index is greater than 125% Reference Index
    Effort <- Last_Effort *1.25
  }

  Rec <- new('Rec')
  Rec@Effort <- Effort
  Rec
}
class(Index_25_Eff) <- 'MP'
```

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