Functional requirements for the Test Cases for CASAL2 v1.0

6 August 2020

1. The Test Cases

The test cases contain the minimum required functionality for CASAL2 version 1.0, as defined by the Development Team. The test cases are based upon real stock assessments that were originally completed using CASAL. In most cases, the assumptions of those models were then modified to encompass the desired functionality; the test cases cannot therefore be compared with any published stock assessment.

All of the test case stock assessment models are age-structured, although some of the observation data may be length-based. MPD results as well as MCMC results are compared.

We intend to add further test cases as they become available and as appropriate. All current test cases are New Zealand stocks.

- HOK is hoki.
- ORH is orange roughy on the Chatham Rise (subarea Andes seamount complex).
- LIN is ling in the sub-Antarctic region.
- BCO is blue cod around the south of the South Island.
- HAK is hake in the sub-Antarctic region.
- SBW is southern blue whiting in the sub-Antarctic region.

2. The models

Multiple versions of CASAL and CASAL2 models are run for each test case, including:

- CASAL - base model (with BetaDiff minimizer)
- CASAL - at least one sensitivity model, e.g., with a lower tolerance value, higher maximum number of function evaluations, higher maximum number of function iterations

- CASAL2 - using ADOL-C with the CASAL flags off, on, and on with lower tolerance value
- CASAL2 - using BetaDiff with the CASAL flags off, on, and on with lower tolerance value
- CASAL2 - using CppAD with the CASAL flags off and on

The CASAL flags in CASAL2 include:

"casal_initialisation switch [true|false]" in the "@initialisation phase" block which runs an extra annual cycle to evaluate equilibrium SSBs to replicate functionality in the legacy version of CASAL, and

"casal_switch [true|false]" in the "@age_length" block(s) which uses the (less accurate) equation for the cumulative normal function as was used in the legacy version of CASAL.

The comparisons will include the MPD estimates as well as the MCMC posterior distributions and diagnostics.

The table below was used as an initial “check list” to ensure that the functionality was included somewhere. It is therefore not exhaustive. For example, the time step functionality was included in all test cases, but requirements were that single and different multiple time

steps were included at some point in the test cases, and so only lists three relevant examples. This is a working document, and when time allows we will update this table to specify the functionality as seen in all of the test cases. When a functionality has not yet been tested this is explicitly stated.

	Process/ functionality	CASAL feature(s)	Test case	Test case notes	Notes
Structure	time steps	can be more than one	HOK	5 steps, of different duration	
			LIN	2 steps, of different duration	
			ORH	1 step; order ageing, recruitment, maturation, instantaneous mortality	
	transitions	hard-wired	all	generic: ageing, migration, maturation	Use Casal2 process @transition_by_category shifts fish between categories; tested in testcases /estimates_with_transformations
	partition	sex, area, stock	HOK	4 areas and 2 stocks with exclusions	set up via categories; hard-wired in CASAL
		sex	LIN		
		maturity	ORH	ORH3B is single sex	Tested in testcases /estimates_with_transformations
	exclusions	area, stock combinations	HOK	Included in Casal2 version of HOK model, but tricky notation in *@categories =.names.* uses 5/8 possible categories, i.e., excludes 3 combinations	Categories factors= Stock.area, so area levels will rotate the fastest (4 levels) and stock is the slowest (2 levels).
	Exclude years in partition		–	New feature in Casal2	Implemented but not tested. Uses the *@categories.years* command can be used to do this since it is designed to allow categories of the partition to exist for a subset of model years. Manual needs examples; main use is for tagging. E.g., *years male.area1=2010:2019* means that partition for males in area1 is only active from 2010 to 2019.
	initialisation	equilibrium	HOK, LIN, ORH	Derived/equilibrium	
		derived	–		CASAL2 derived keyword Implemented but not tested.
		cinitial	–		CASAL2 cinitial keyword Implemented but not tested.
		iterative	–		CASAL2 iterative keyword
Processes	ageing	plus group yes	all	defined process	
	fishing mortality	many fisheries	all	defined process	
		retained catch	BCO	New functionality	
		Baranov	–	Not implemented in CASAL2	
	natural mortality	age-dependent	HOK LIN	Keyword double_exponential	Defined process
		constant by sex	SBW		Specified as average and difference between sexes.
		constant	ORH, HAK		

maturity	Hard-wired	ORH	Defined as category: partition and transition	Covered in partitions
	Logistic	ORH	Logistic-producing (partition)	
		BCO		BCO has logistic maturity outside the partition
	Age-dependent	LIN, HAK	Observation type	Any form of ogive can be estimated. By sex in HAK.
	All_values_bounded	HOK	Maturity can be defined by area and time step (partition)	In hoki, selectivity = all-values_bounded, spawning area in partition, via migrations & area & timestep
Migration	Hard-wired	HOK (5, by sex and age)	Transition by category	
recruitment	S-R relationship,	HOK (2 stocks), ORH, LIN	Beverton-Holt	
		–	Ricker	Not yet implemented
	YCS, YCS averaged over some years	all		
length-at-age	von Bertalanffy	HOK/LIN		
	Schnute	HAK		
	empirical mean length-at-age data	SBW, ORH	Type data	
CV on length-at-age	Constant	–	cv first = cv last (one cv)	Not explicitly tested, but constant by sex tested.
	Constant by sex	HAK	cv male and cv female	
	cv 1 and cv 2	ORH	cv first and cv last; linear interpolation & estimates these too	Linear interpolation in natural space, by age or length
	sd 1 and sd 2	–	sd first and sd last	Not yet implemented.
weight-at-length	mean weight-at-length	ORH	all	
		–	By sex	Not yet tested.
	calc mean weight (with bias correction)	ORH		
ageing error	off-by-one	BCO		
	normal	LIN		
	misclassification matrix	HOK		
Selectivity ogives	a50 shifts, double normal,	HOK	time-varying Command: Type: exogeneous	
	Logistic	ORH/ LIN		
	double normal,	HOK/ LIN		
	constant	HOK		
	logistic capped	LIN		

		double exponential	HOK/ LIN	In M-by-age setting	Uses selectivity to do this
		length-based logistic	BCO		
		Length based double normal	–		Implemented but not yet tested.
		all_values_bounded	HOK/LIN	Migration selectivity	
Observations	observations	acoustic biomass	HOK	Type biomass: Cook Strait only; west coast (i.e., different parts of partition)	
		trawl biomass	HOK	Type biomass: Chat. Rise; sub-Ant	
			LIN	Type biomass: Tangaroa summer and autumn	
		CPUE	ORH	biomass	
		age freq: fishery	HOK, LIN	Using Casal2 process removals by age + ageing error; process error of type N with multinomial	
		age freq: survey	HOK	2x proportions at age,	
			LIN	2x proportions at age	
		length freq: fishing	BCO	age-based model	
		length freq: survey	–	age-based model	Implemented but not tested.
		Proportions migrating	HOK	process_proportions_migrating	
		Maturity at length or age	–		Implemented proportion mature at age; at-length not implemented. Not tested.
		Age-length	–	For estimation of growth. Not in Casal2 yet, but can estimate Linf, K, t0 from length compositions (not recommended)	Not yet implemented.
Estimation	estimation	MPD	all		
		MCMC; specify free parameters, prior distributions	all		
	Estimate catchability	Nuisance q	ORH,	@additional_prior/type catchability[Catchability_label].q @catchability /type nuisance	Not explicitly defined in @estimate block
		Free q	HOK, LIN		
		ratio q	–		Not yet implemented (Maybe @additional__prior/.type=lognormal/beta).
	Estimate process error	Normal/lognormal = process_cv	SBW	any observation with a likelihood component sub-cmd “process_error”	
		Multinomial = N	–		
	Estimate B0	2 stock	HOK	Beta prior on proportion + log transform	
		1 stock	ORH, LIN	Uniform-log prior	

		B0 transformation	HOK	@estimate_transformation/type log_sum Specific in CASAL to Bo, but generic in Casal2	
	YCS	Constant	ORH		
		Estimate	HOK, LIN	Lognormal prior	
	Equal parameters	Same command	HOK	M over west/east stocks. East and west fishery selectivity	
	Phased estimation				Implemented but not yet tested.
	penalty	catch limits	all		
		YCS difference	HOK	east and west 2016; @additional_prior.type element_difference	@additional_prior.type element_difference; YCS2016 tied together for E&W; Selectivity tied together for E&W at age 8yr
		ogive difference	HOK	Migration rate at age 8; @additional_prior.type element_difference	
		smooth vectors	–		Implemented but not yet tested.
	likelihoods	multinomial	all		
		lognormal	all		
		normal	–		Not yet tested.
	prior distributions	uniform	all		
		uniform-log	LIN		
		lognormal	all		
		normal	all		Normal-by-stdev (HOK)
		beta	HOK		
Outputs	Projections	point-based or samples	SBW	empirical randomizing YCS	
	derived variables	SSB	All	CASAL provides SSB only	
		other	–		New functionality not yet tested.
	residuals	usual, Pearson, normalized	all	In fit report	
	outputs	parameters, fits, discards/removals/ actual catches, Partition (numbers), true YCS, YCS, recruitment,	all		

	SSB, total/vuln bio, fishing pressure, selectivities, Observations, nuisance qs, Mean weight at age and length, mean length at age, by timestep Derived parameters (e.g., F40%)	
Objective function log-L		all
size-weight		all
time-varying	exogenous (a50)	HOK
	external data links (time series)	–