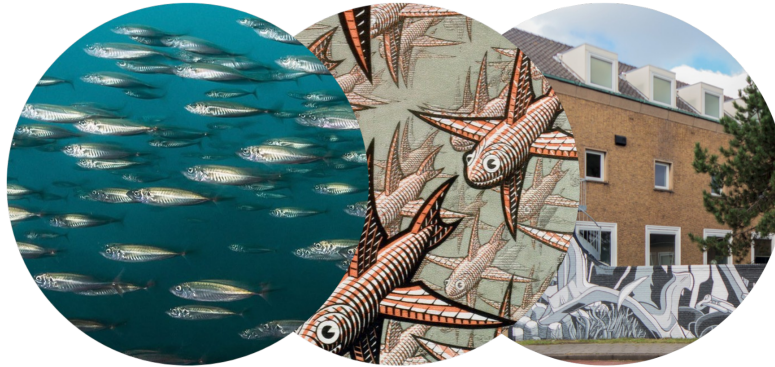


Management Strategy Evaluation (MSE) for SPRFMO jack mackerel

Progress since SCW17 (WUR)

July 2026 | Iago Mosqueira & Benoît Bergès (Wageningen Marine Research)

WAGENINGEN
UNIVERSITY & RESEARCH

Progress since workshop SC17

Progress since workshop SC17

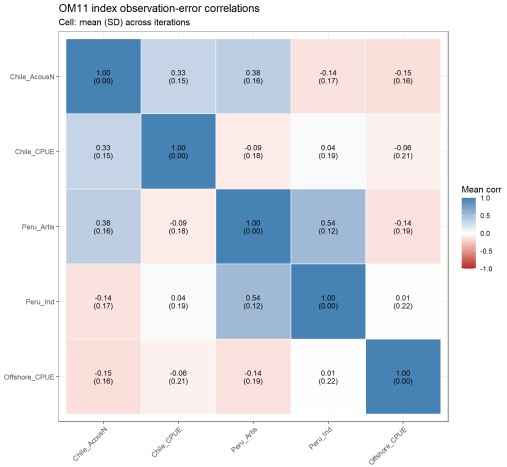
- Performance statistics now include VB/VB_{2025} and `UMSY`, VB/MSY
- Index residuals now include cross correlation between indices
- Added a slope HCR to the tuning set
- Powerramp (Chilean HCR peoposal) corrected to avoid jumps around lim
- Further model tuning carried out on `SB0green`, new Kobe green based on `SB0MSY` metric

OM conditioning

OM grid

short	model	origin	opt	set
om11	h1_0.16	2030	065	ref
om12	h1_0.16h	2030	080	rob
om13	h1_1.14	2020	065	rob
om21	h2_0.16	2030	065	rob
om22	h2_0.16h	2030	080	rob
om23	h2_1.14	2020	065	rob
om21_1	h2_0.16_mov	2030	065_mov	rob
om11_1	h1_0.16_selex	2030	065_selex	rob
om11_2	h1_0.16_lowrec	2030	065_reclow	rob
om11_3	h1_0.16_cycle	2030	065_cycle	rob

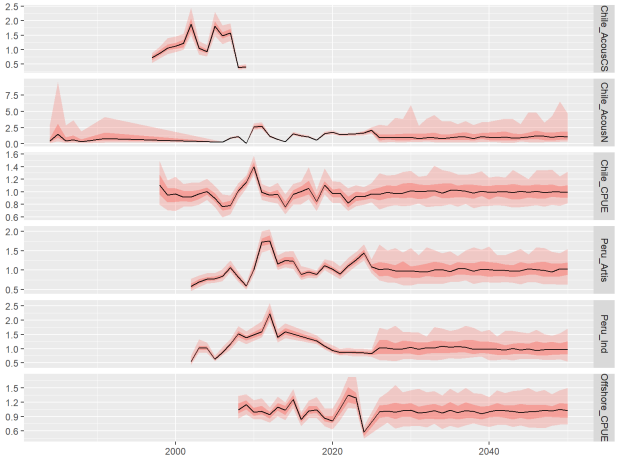
Conditioning of index residuals - cross correlation matrix



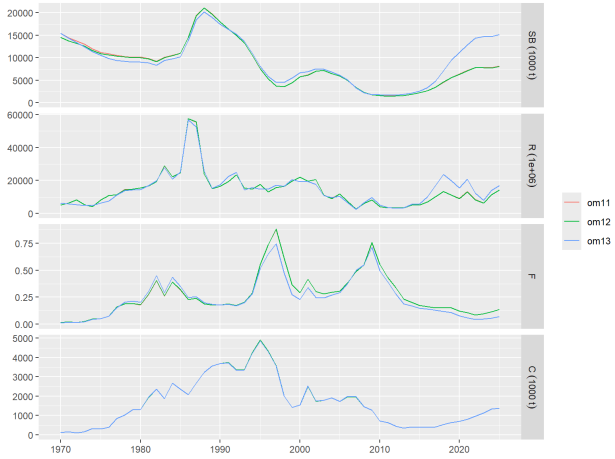
Conditioning of index residuals - SD and autocorrelation

index	sd	rho
Chile_AcousN	0.897	0.0935
Chile_CPUE	0.171	0.2830
Peru_Artis	0.302	0.5810
Peru_Ind	0.348	0.6280
Offshore_CPUE	0.239	-0.0365

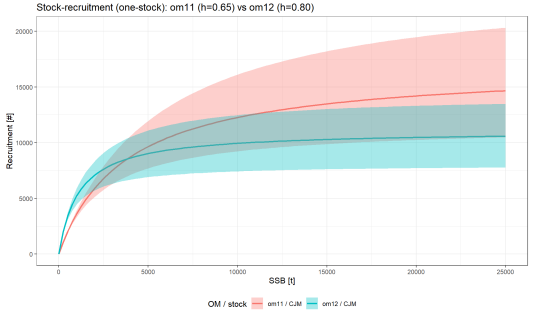
Conditioning of index residuals



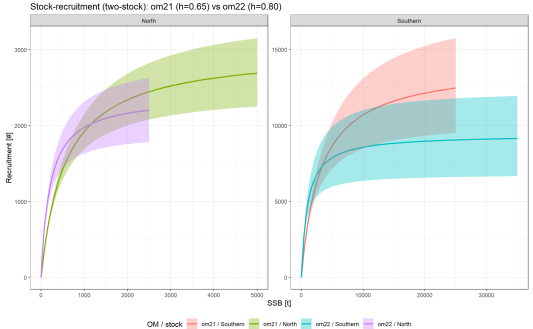
OM contrast - jjm 0.16 vs 1.14



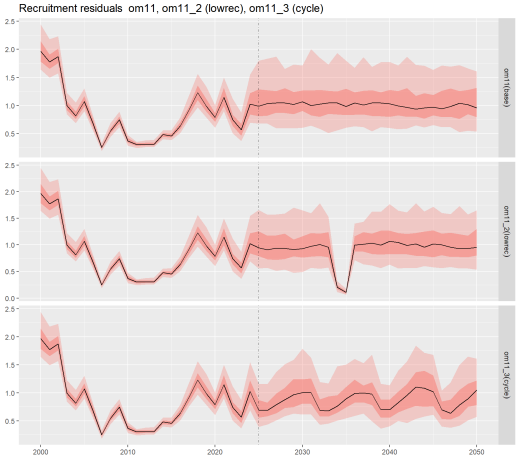
OM contrast - h1 stock recruitment functions



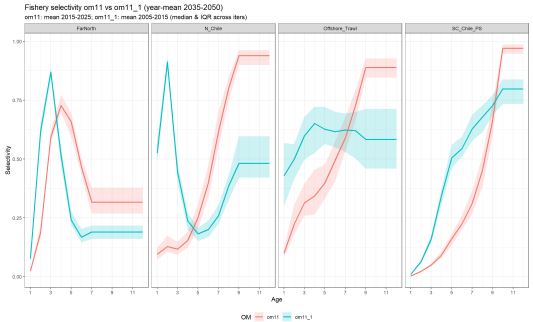
OM contrast - h2 stock recruitment functions



OM contrast - recruitment crash and recruitent cycle



OM contrast - selectivity



Tuning approach

Tuning approach

iterative steps:

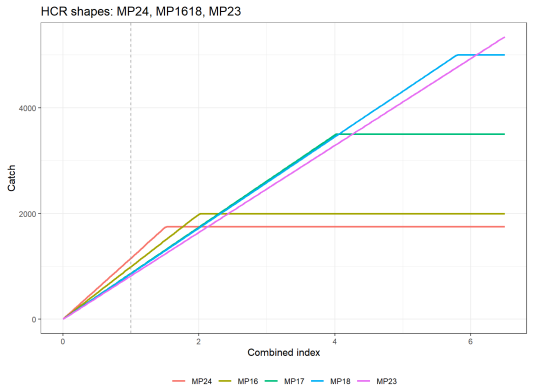
- HS target trade-off
- HS min/lim impact
- Powerramp target trade-off
- Powerramp min/lim impact
- Powerramp vs HS trade-off
- Alternative empirical estimator setups
- h2 red face test

MP tuning - Hockeystick (HS)

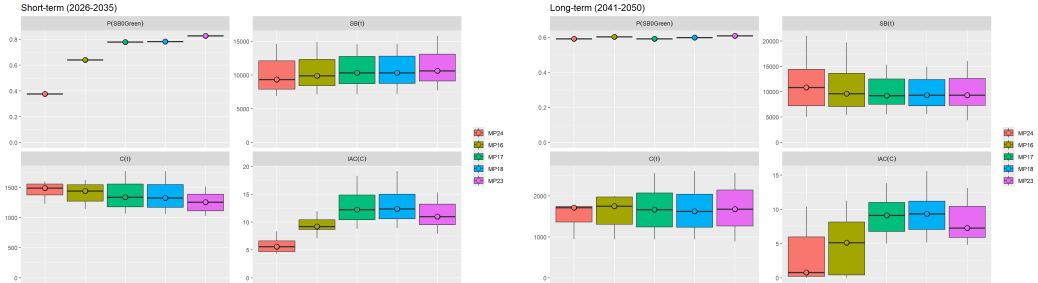
HS target trade-off - HCRs

mp	hcr	estimator	metric	output	target	min	lim	trigger	dlow	dupp	slope
tun24	hockeystick	all.idx	mean	catch	1750	0	0	1.51	0.85	1.2	1160
tun16	hockeystick	all.idx	mean	catch	2000	0	0	2.01	0.85	1.2	994
tun17	hockeystick	all.idx	mean	catch	3500	0	0	4.02	0.85	1.2	872
tun18	hockeystick	all.idx	mean	catch	5000	0	0	5.80	0.85	1.2	863
tun23	slope	all.idx	mean	catch	NA	0	0	NA	0.85	1.2	822

HS target trade-off - HCRs



HS target trade-off - results



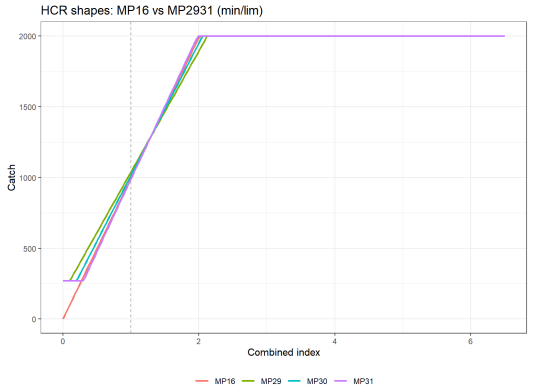
HS target trade-off - take home message

- choice of target value matters for HS performance
- Lower target decreases IACC in both short and long term
- Lower target: higher catch with lower SB in the short term, but higher SB in the long term
- MP24 (target=1750) low SB0green in the short term
- MP16 (target=2000) as a potentially good candidate MP to go forward (>60% SB0green short and long term, high catch/SB in the long term, low IAC long/short term)

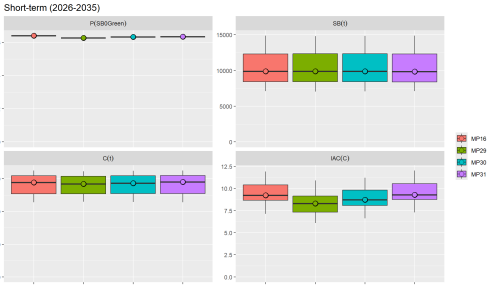
HS min/lim impact - HCRs

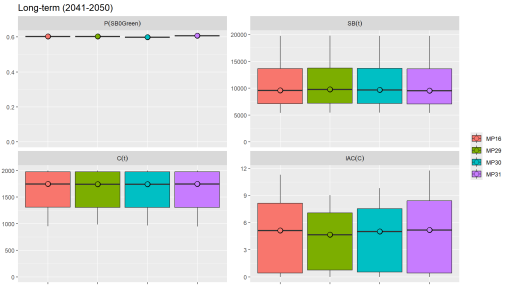
mp	hcr	estimator	metric	output	target	min	lim	trigger	dlow	dupp	slope
tun16	hockeystick	all.idx	mean	catch	2000	0	0.0	2.01	0.85	1.2	994
tun29	hockeystick	all.idx	mean	catch	2000	270	0.1	2.12	0.85	1.2	941
tun30	hockeystick	all.idx	mean	catch	2000	270	0.2	2.05	0.85	1.2	973
tun31	hockeystick	all.idx	mean	catch	2000	270	0.3	1.98	0.85	1.2	1010

HS min/lim impact - HCRs



HS min/lim impact - results





HS min/lim impact - take home message

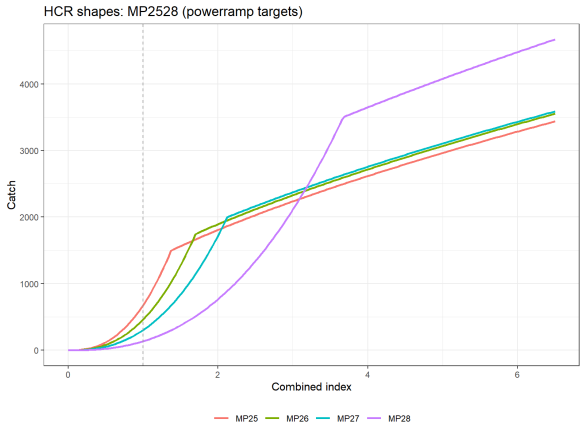
- Marginal effect on SB, catch and SB0green
- Marginal effect on IACC at lowest lim value (0.1)
- MP29 (lim=0.1) as HS optimal run

MP tuning - Powerramp (PR)

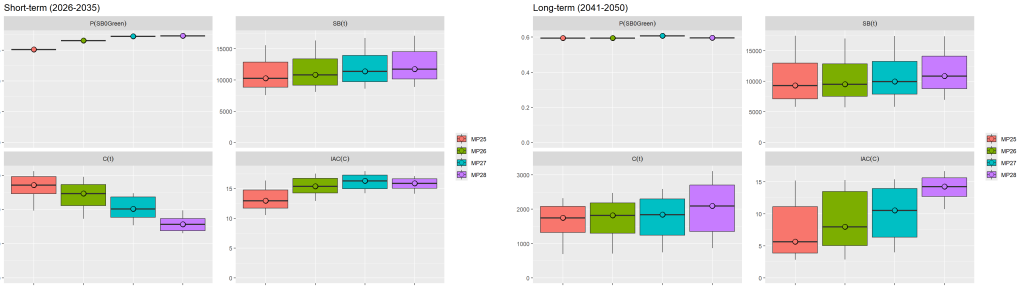
powerramp target trade-off - HCRs

mp	hcr	estimator	metric	output	target	min	lim	trigger	dlow	dupp	slope
tun25	powerramp	all.idx	mean	catch	1500	0	0	1.38	0.85	1.2	NA
tun26	powerramp	all.idx	mean	catch	1750	0	0	1.70	0.85	1.2	NA
tun27	powerramp	all.idx	mean	catch	2000	0	0	2.12	0.85	1.2	NA
tun28	powerramp	all.idx	mean	catch	3500	0	0	3.67	0.85	1.2	NA

powerramp target trade-off - HCRs



powerramp target trade-off - results



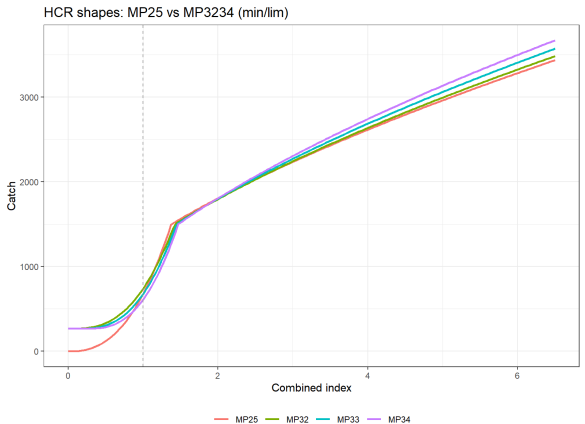
powerramp target trade-off - take home message

- choice of target value matters for powerramp performance
- Lower target gives lower IACC in both short and long term
- Lower target increases catch in the short term but decreases it in the long term
- All choices of target value have acceptable SB0green in the short and long term
- MP25 (target=1500) as a potentially good candidate MP to go forward (>60% SB0green short and long term, high catch/SB in the long term, low IAC long/short term)

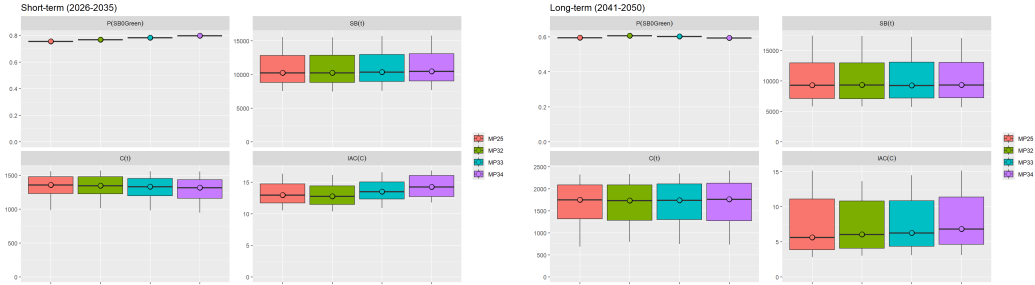
powerramp min/lim impact - HCRs

mp	hcr	estimator	metric	output	target	min	lim	trigger	dlow	dupp	slope
tun25	powerramp	all.idx	mean	catch	1500	0	0.0	1.38	0.85	1.2	NA
tun32	powerramp	all.idx	mean	catch	1500	270	0.1	1.42	0.85	1.2	NA
tun33	powerramp	all.idx	mean	catch	1500	270	0.2	1.45	0.85	1.2	NA
tun34	powerramp	all.idx	mean	catch	1500	270	0.3	1.47	0.85	1.2	NA

powerramp min/lim impact - HCRs



powerramp min/lim impact - results



powerramp min/lim impact - take home message

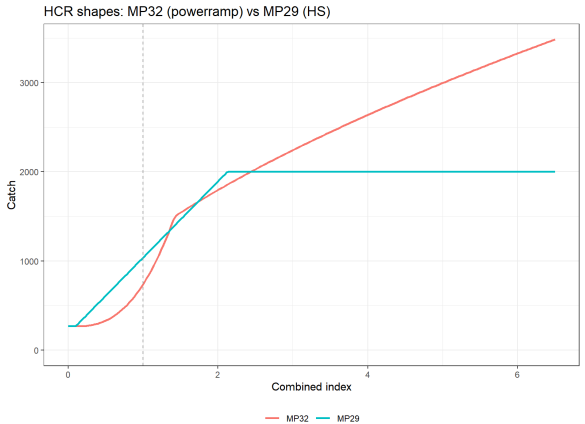
- Marginal decrease in short term catch with incresing lim value
- Comparable performance in the long term with different lim values
- MP32 (lim=0.1) as powerramp optimal run

MP tuning - powerramp vs HS

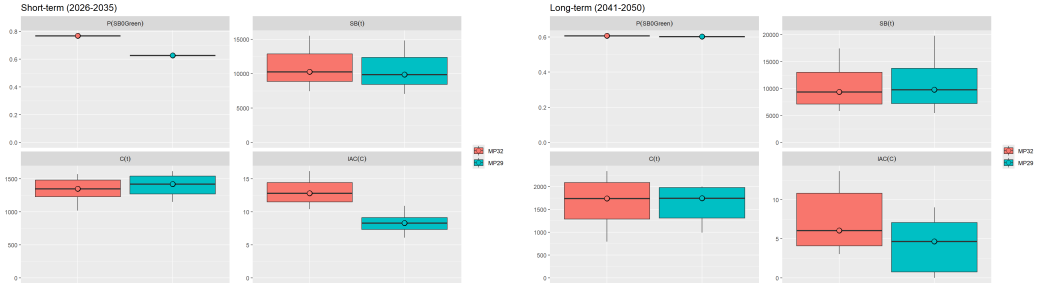
powerramp vs HS trade-off - HCRs

mp	hcr	estimator	metric	output	target	min	lim	trigger	dlow	dupp	slope
tun32	powerramp	all.idx	mean	catch	1500	270	0.1	1.42	0.85	1.2	NA
tun29	hockeystick	all.idx	mean	catch	2000	270	0.1	2.12	0.85	1.2	941

powerramp vs HS trade-off - HCRs



powerramp vs HS trade-off - results



powerramp vs HS trade-off - take home message

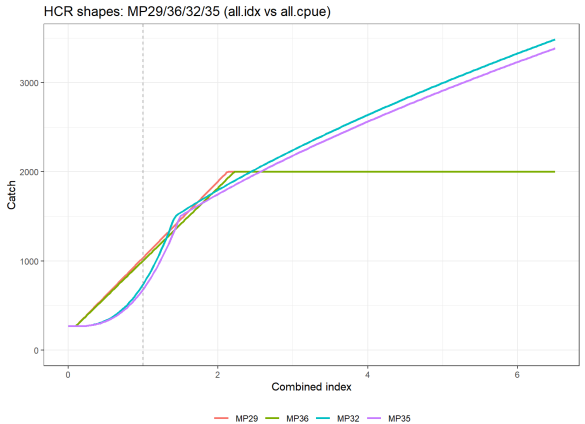
- HS provides lower IACC in both short and long term
- HS provides slightly higher catches in the short term
- HS HCR MP29 (target=2000) as a potentially good candidate MP

Alternative empirical estimator setups

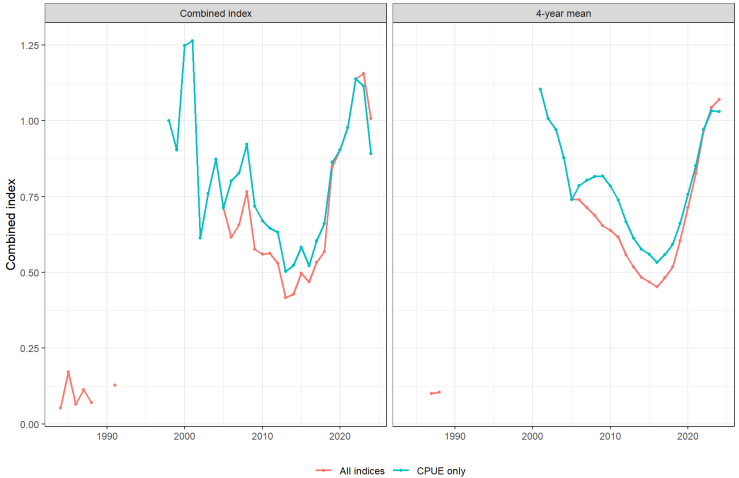
CPUE indices only - HCRs

mp	hcr	estimator	metric	output	target	min	lim	trigger	dlow	dupp	slope
tun29	hockeystick	all.idx	mean	catch	2000	270	0.1	2.12	0.85	1.2	941
tun36	hockeystick	all.cpue	mean	catch	2000	270	0.1	2.22	0.85	1.2	901
tun32	powerramp	all.idx	mean	catch	1500	270	0.1	1.42	0.85	1.2	NA
tun35	powerramp	all.cpue	mean	catch	1500	270	0.1	1.49	0.85	1.2	NA

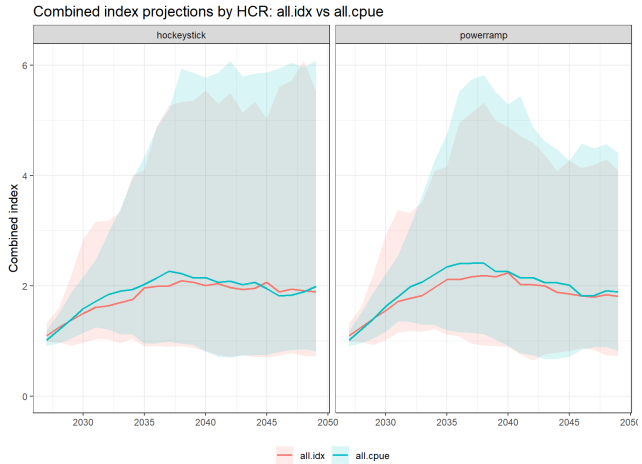
CPUE indices only - HCRs



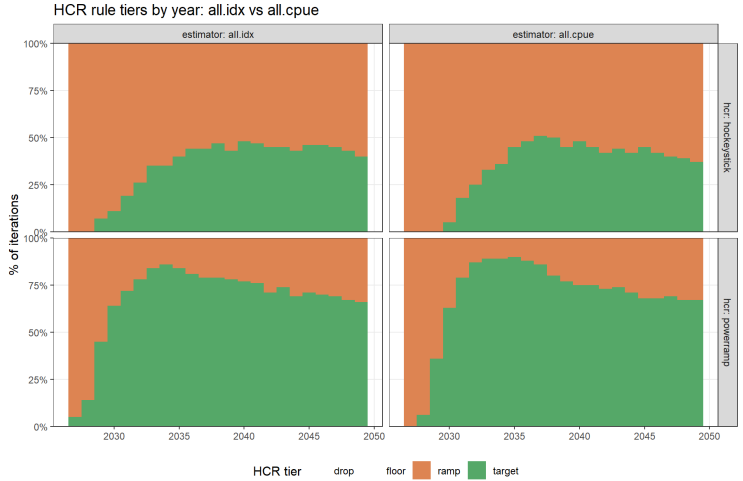
CPUE indices only - time series historical



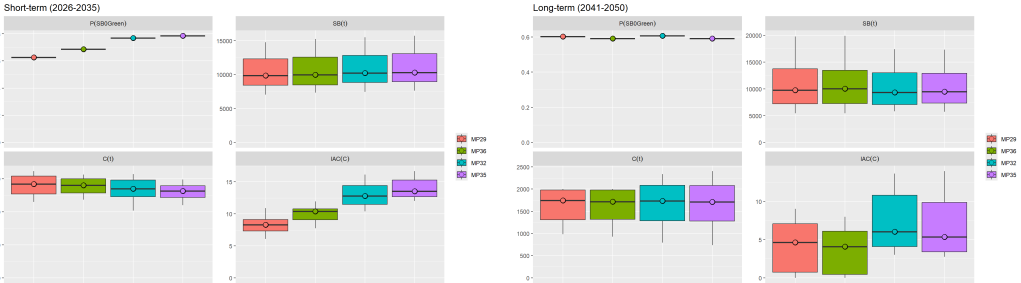
CPUE indices only - time series of indices



CPUE indices only - time series of tiers



CPUE indices only - results



CPUE indices only - take home message

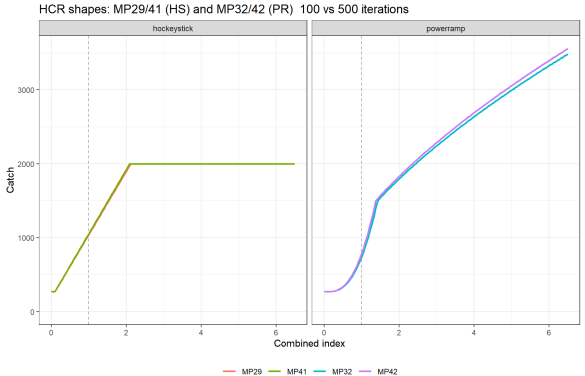
- all.cpue indices combination is more responsive
- all.cpue provides higher IACC and lower catches in the short term
- all.cpue provides lower IACC and similar catches in the long term
- Using cpue indices only could be an option but impact is limited with drawbacks

MP tuning - number of replicates

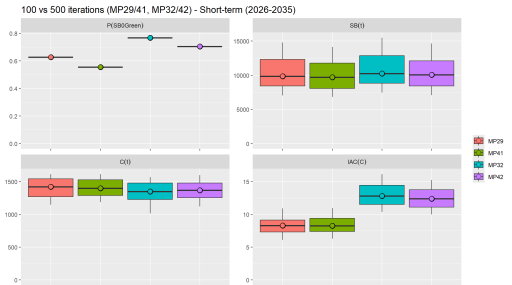
number of replicates - HCRs

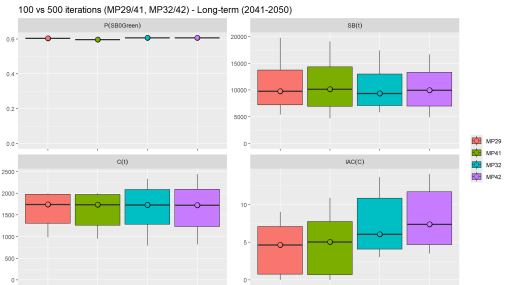
mp	label	om_iters	hcr	estimator	metric	output	target	min	lim	trigger	dlow	dupp	slope
tun29	MP29	100	hockeystick	all.idx	mean	catch	2000	270	0.1	2.12	0.85	1.2	941
tun32	MP32	100	powerramp	all.idx	mean	catch	1500	270	0.1	1.42	0.85	1.2	NA
tun41	MP41	500	hockeystick	all.idx	mean	catch	2000	270	0.1	2.09	0.85	1.2	955
tun42	MP42	500	powerramp	all.idx	mean	catch	1500	270	0.1	1.38	0.85	1.2	NA

number of replicates - HCRs



number of replicates - results



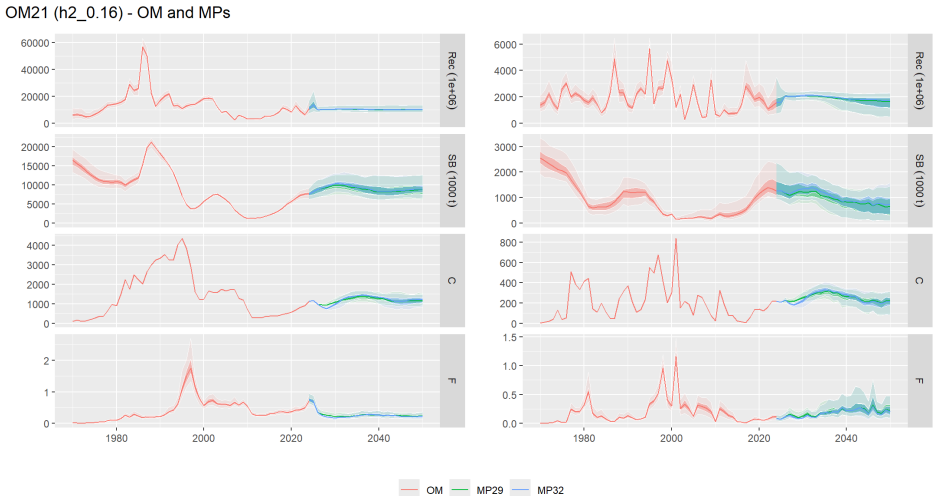


number of replicates - take home message

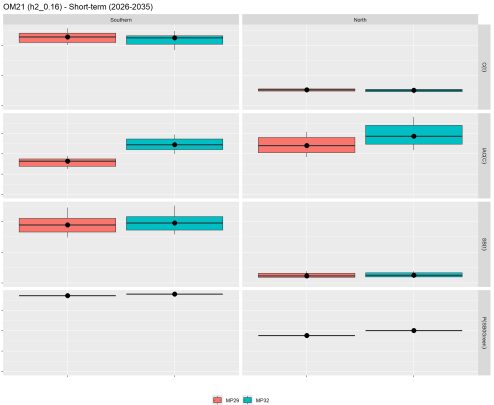
- Tuning with 100 and 500 iterations gives similar results with very similar triggers
- Performance of the MP is only slightly affected by the number of replicates

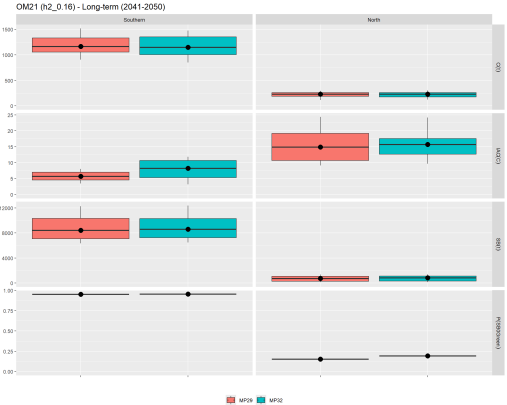
MP tuning - h2 red face test

om21 red face test - time series by stock



om21 red face test - results





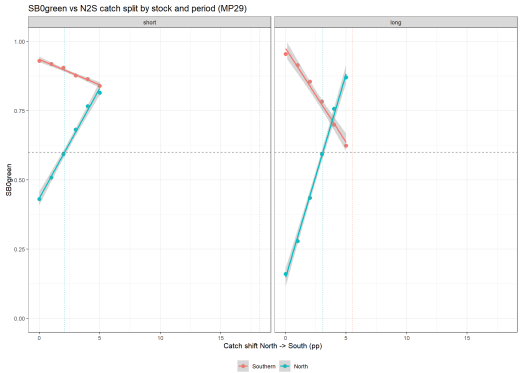
om21 red face test - take home message (1/2)

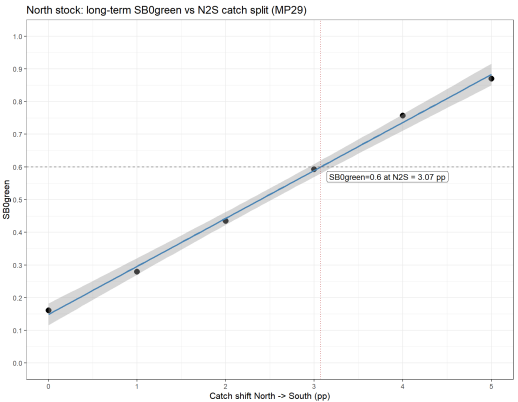
- Decline of the northern stock in the short term
- Risk for the North stock is well below 60% SB0green in the short and long term
- Risk for the dominating southern stock is above 60% SB0green in the short and long term (red face tests)
- Current split in catch is not proportionate to the stock sizes

om21 red face test - varying catch split

split	N_Chile	SC_Chile_PS	FarNorth	Offshore_Trawl
N2S_0pp	0.0716	0.711	0.1650122	0.0523
N2S_1pp	0.0725	0.720	0.1550122	0.0529
N2S_2pp	0.0734	0.728	0.1450122	0.0536
N2S_3pp	0.0742	0.737	0.1350122	0.0542
N2S_4pp	0.0751	0.745	0.1250122	0.0548
N2S_5pp	0.0759	0.754	0.1150122	0.0554

om21 red face test - catch split vs SB0green





om21 red face test - take home message (2/2)

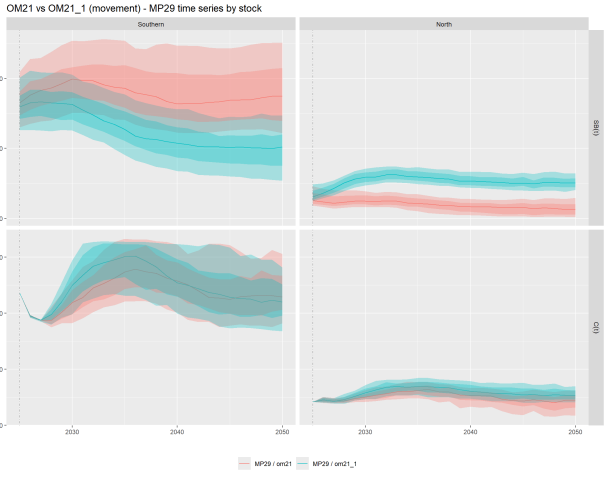
- A decrease of catch split for the FarNorth fleet by 3.07% is required to satisfy the 60% SB0green for the north stock in the long term
- A transfer of 3.07% of the catch from the FarNorth keeps SB0green for the Southern stock well above 60%

Robustness tests - h2 with movement

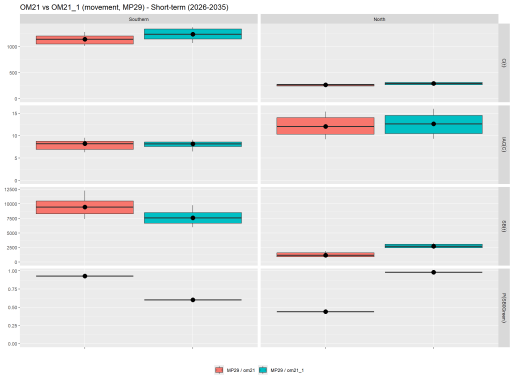
h2 with movement - table

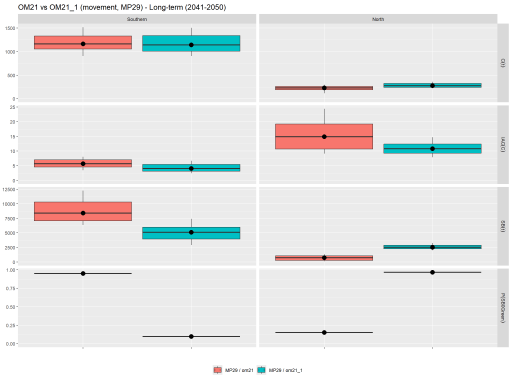
run	mp	om	label	hcr	estimator	target	min	lim	trigger	dlow	dupp
tun29_om21	tun29	om21	MP29	hockeystick.hcr	all.idx	2000	270	0.1	2.12	0.85	1.2
tun29_om21_1	tun29	om21_1	MP29	hockeystick.hcr	all.idx	2000	270	0.1	2.12	0.85	1.2

h2 with movement - time series



h2 with movement - results

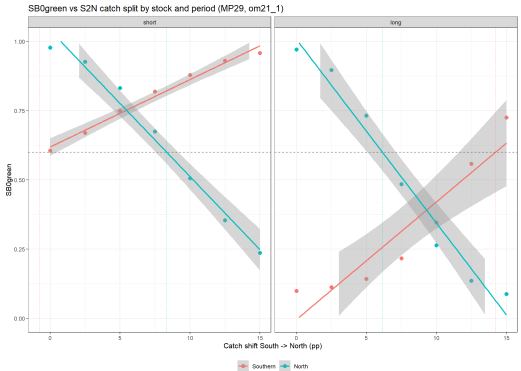


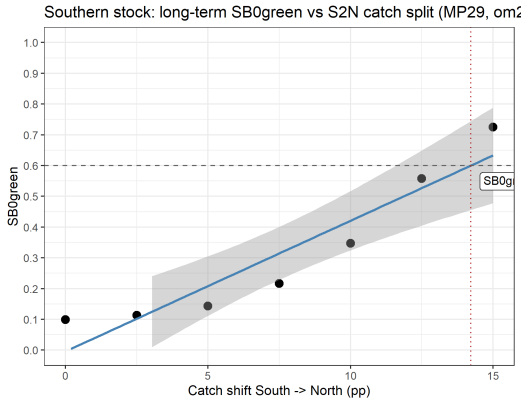


h2 with movement - varying catch split

split	N_Chile	SC_Chile_PS	FarNorth	Offshore_Trawl
S2N_0pp	0.0716	0.711	0.165	0.0523
S2N_2.5pp	0.0695	0.690	0.190	0.0507
S2N_5pp	0.0673	0.668	0.215	0.0492
S2N_7.5pp	0.0652	0.647	0.240	0.0476
S2N_10pp	0.0631	0.626	0.265	0.0460
S2N_12.5pp	0.0609	0.605	0.290	0.0445
S2N_15pp	0.0588	0.583	0.315	0.0429

h2 with movement - catch split vs SB0green





h2 with movement - take home message

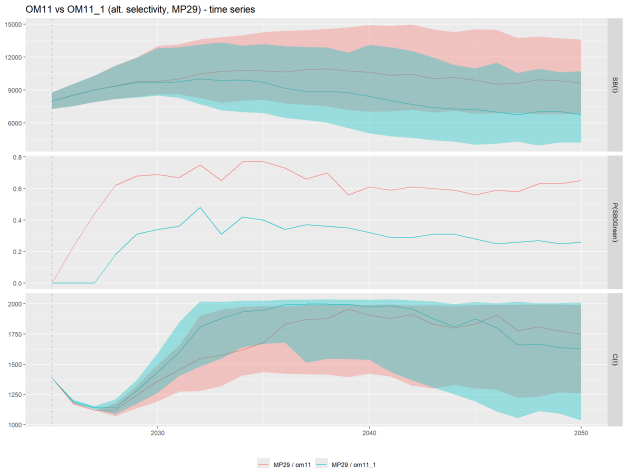
- Impact of movement on the performance is substantial in both the short and long term
- Movement rate transfers SB from the Southern stock to the North stock in the short term
- Keeping the same split in catches leads to a low SB0green for the Southern stock in the long term
- There is no change in catch split that resolves SB0green for the southern and North stock when movement is included
- Caveat to the simulation is that the catch split is time invariant whilst change in stock level is dynamic over the projected period

Robustness tests - alternative selectivity

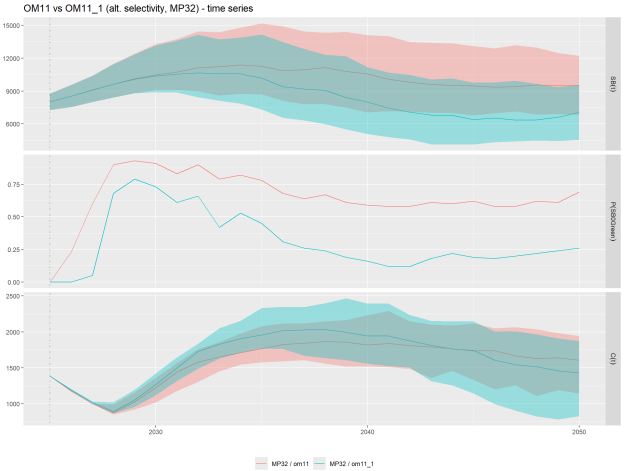
Robustness tests - alternative selectivity - HCRs

run	mp	om	label	hcr	estimator	target	min	lim	trigger	dlow	dupp
tun29_om11_1	tun29	om11_1	MP29	hockeystick	all.idx	2000	270	0.1	2.12	0.85	1.2
tun32_om11_1	tun32	om11_1	MP32	powerramp	all.idx	1500	270	0.1	1.42	0.85	1.2
tun29_om11	tun29	om11	MP29	hockeystick	all.idx	2000	270	0.1	2.12	0.85	1.2
tun32_om11	tun32	om11	MP32	powerramp	all.idx	1500	270	0.1	1.42	0.85	1.2

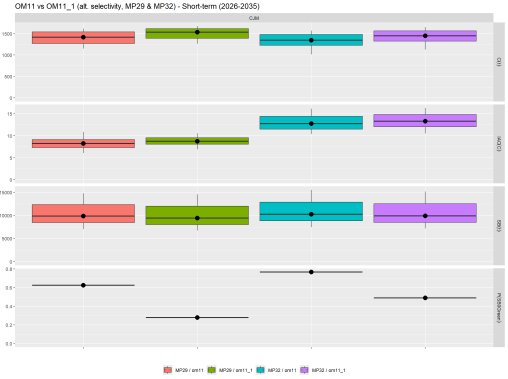
Alternative selectivity om11 vs om11_1 - time series

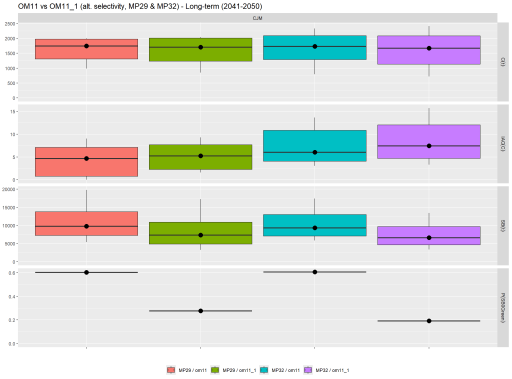


Alternative selectivity om11 vs om11_1 - time series



Alternative selectivity om11 vs om11_1 - results





Alternative selectivity om11 vs om11_1 - take home message

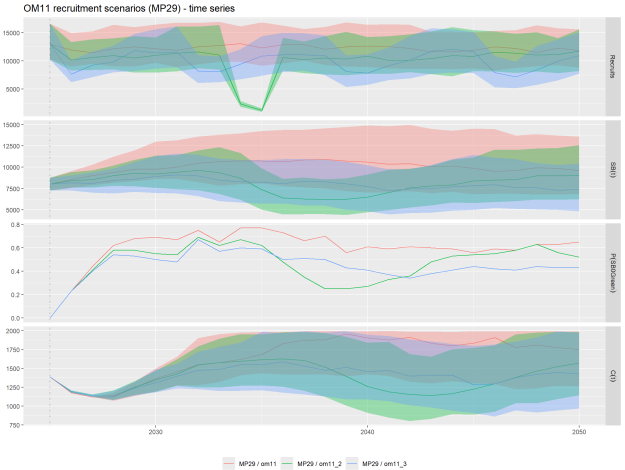
- Alternative selectivity induces catches on younger/smaller fish, resulting in less SB/catch
- MPs deliver similar catch levels but at much lower SB0green levels
- Satisfying SB0green with different selectivity requires specific tuning and likely lower catch levels
- MP29 (HS) gives a better trade-off in the long term compared to PR (MP32)

Robustness tests - low recruitment scenarios

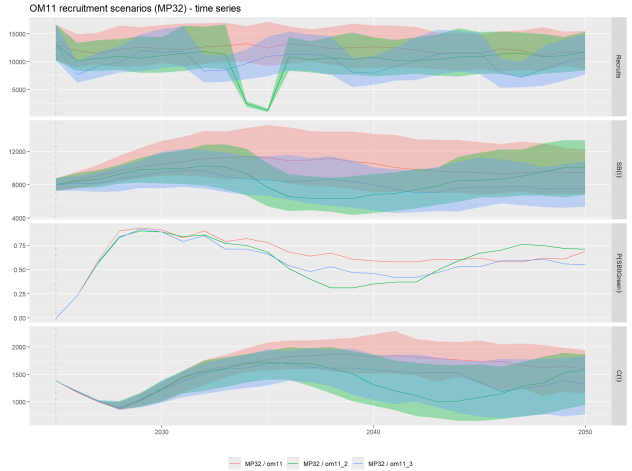
Robustness tests - low recruitment scenarios - HCRs

run	mp	om	label	hcr	estimator	target	min	lim	trigger	dlow	dupp
tun29_om11_2	tun29	om11_2	MP29	hockeystick	all.idx	2000	270	0.1	2.12	0.85	1.2
tun32_om11_2	tun32	om11_2	MP32	powerramp	all.idx	1500	270	0.1	1.42	0.85	1.2
tun29_om11_3	tun29	om11_3	MP29	hockeystick	all.idx	2000	270	0.1	2.12	0.85	1.2
tun32_om11_3	tun32	om11_3	MP32	powerramp	all.idx	1500	270	0.1	1.42	0.85	1.2
tun29_om11	tun29	om11	MP29	hockeystick	all.idx	2000	270	0.1	2.12	0.85	1.2
tun32_om11	tun32	om11	MP32	powerramp	all.idx	1500	270	0.1	1.42	0.85	1.2

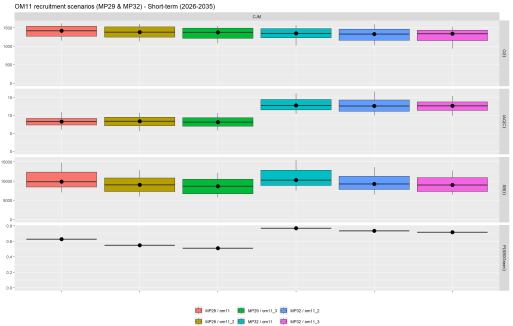
om11 recruitment scenarios - time series



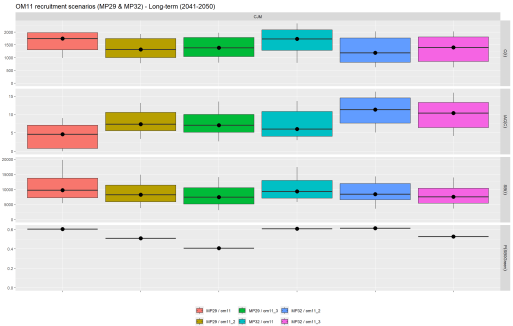
om11 recruitment scenarios - time series



om11 recruitment scenarios - results



om11 recruitment scenarios - results



om11 vs om11_2 and om11_3 - take home message

- For om11_3, SB is still in recovery phase at the 2050
- Under both the cyclic (om11_3) and crash (om11_2) scenarios, catch levels are lower in the long term with higher IACC
- MP32 (PR) is more resilient to both the cyclic (om11_3) and crash (om11_2) scenarios
- MP32 (PR) gives a better recovery in the long term compared to MP29 (HS)

Sensitivity test - Banking and borrowing

Banking and borrowing - to be added

Summary of results and take home message

Summary of results and take home message

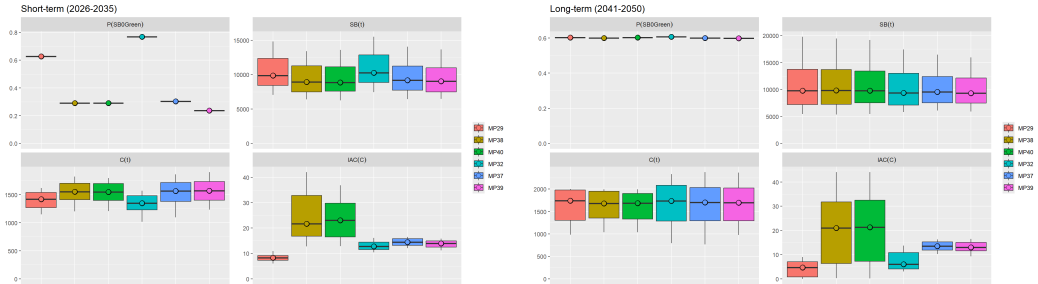
- The MP29 (HS, catch plateau=2000t) is the optimal MP, MP32 (PR, catch breakpoint=1500t) is an alternative
- The use of CPUE indices only is a potential alternative to using all indices
- The red face test passes for the Southern stock and requires a decrease of catch split for the FarNorth fleet by 3.07% to also satisfy risk on the North stock
- Inclusing movement in the simulation leads to a substantial impact on the performance of the MPs on the Southern stock
- With the inclusion of movement, no fixed catch share can resolve SB0green for the Southern and North stock in the long term
- Selectivity is impactful on the performances of the MPs with reduced sb0green. MP29 (HS, catch plateau=2000t) gives a better trade-off in the long term compared to MP32 (PR)

Annexes

Annex 1 - shortcut and perfect sa - HCRs

mp	hcr	estimator	metric	output	target	min	lim	trigger	dlow	dupp	slope
tun29	hockeystick	all.idx	mean	catch	2000	270	0.1	2.120	0.85	1.2	941
tun38	hockeystick	shortcut.sa	depletion	catch	2000	270	0.1	0.455	0.85	1.2	4400
tun40	hockeystick	shortcut.sa	depletion	catch	2000	270	0.1	0.463	0.85	1.2	4320
tun32	powerramp	all.idx	mean	catch	1500	270	0.1	1.420	0.85	1.2	NA
tun37	powerramp	shortcut.sa	depletion	catch	1500	270	0.1	0.341	0.85	1.2	NA
tun39	powerramp	perfect.sa	depletion	catch	1500	270	0.1	0.335	0.85	1.2	NA

Annex 1 - shortcut and perfect sa - results



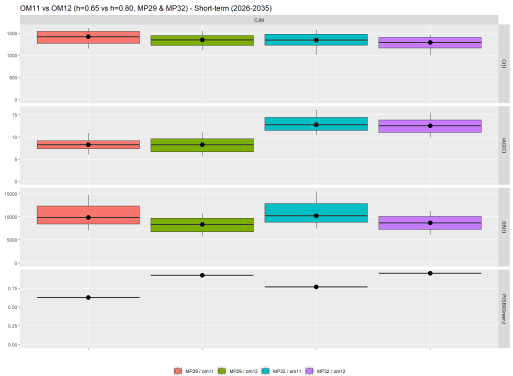
Annexe 1 - shortcut and perfect sa - take home message

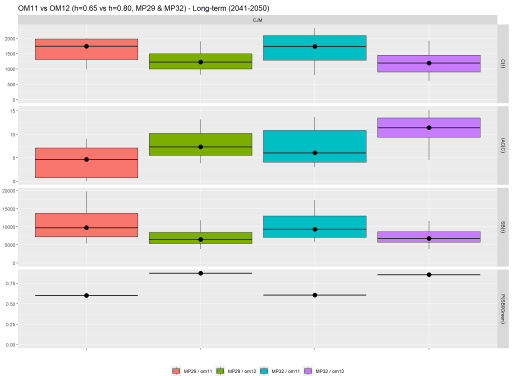
- shortcut and perfect sa provide similar performance
- shortcut and perfect sa give higher catch in the short term which reduces performances in the long term
- shortcut and perfect sa better optimizes the short term with a trade-off in the long term relative to empirical manamgement procedures
- The use of empirical management procedures is precautionary

Annexe 2 - h1 alternative recruitment robustness test om11 vs om12

run	mp	om	label	hcr	estimator	target	min	lim	trigger	dlow	dupp
tun29_om12	tun29	om12	MP29	hockeystick	all.idx	2000	270	0.1	2.12	0.85	1.2
tun32_om12	tun32	om12	MP32	powerramp	all.idx	1500	270	0.1	1.42	0.85	1.2
tun29_om11	tun29	om11	MP29	hockeystick	all.idx	2000	270	0.1	2.12	0.85	1.2
tun32_om11	tun32	om11	MP32	powerramp	all.idx	1500	270	0.1	1.42	0.85	1.2

Annexe 2 - h1 alternative recruitment robustness test om11 vs om12

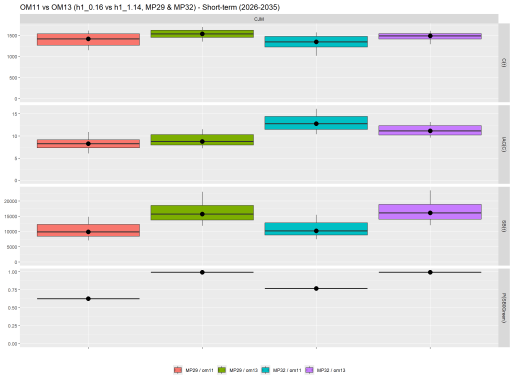


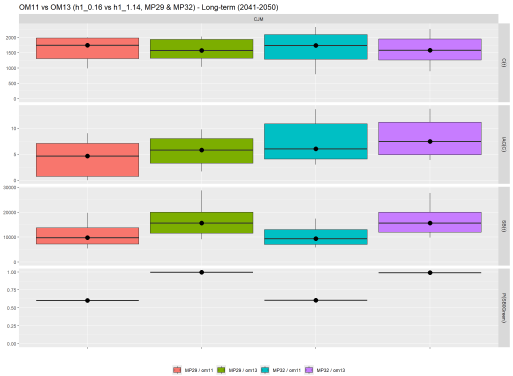


Annexe 3 - h1 model 1.14 robustness test om11 vs om13

run	mp	om	label	hcr	estimator	target	min	lim	trigger	dlow	dupp
tun29_om13	tun29	om13	MP29	hockeystick	all.idx	2000	270	0.1	2.12	0.85	1.2
tun32_om13	tun32	om13	MP32	powerramp	all.idx	1500	270	0.1	1.42	0.85	1.2
tun29_om11	tun29	om11	MP29	hockeystick	all.idx	2000	270	0.1	2.12	0.85	1.2
tun32_om11	tun32	om11	MP32	powerramp	all.idx	1500	270	0.1	1.42	0.85	1.2

Annexe 3 - h1 model 1.14 robustness test om11 vs om13

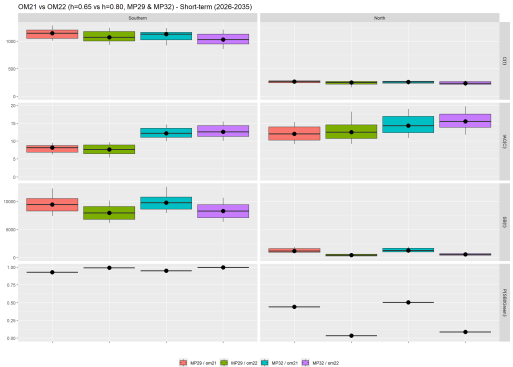


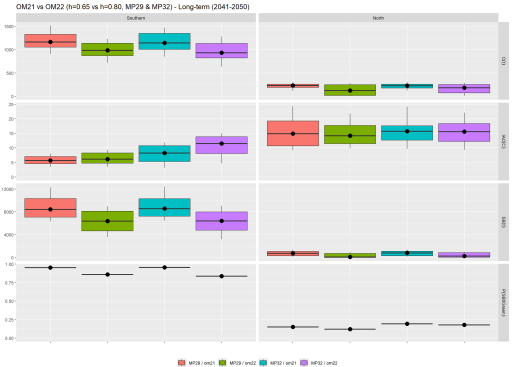


Annexe 4 - h2 alternative recruitment robustness test om21 vs om22

run	mp	om	label	hcr	estimator	target	min	lim	trigger	dlow	dupp	label_plot
tun29_om21	tun29	om21	MP29	hockeystick.hcr	all.idx	2000	270	0.1	2.12	0.85	1.2	MP29 / om21
tun29_om22	tun29	om22	MP29	hockeystick.hcr	all.idx	2000	270	0.1	2.12	0.85	1.2	MP29 / om22
tun32_om21	tun32	om21	MP32	powerramp	all.idx	1500	270	0.1	1.42	0.85	1.2	MP32 / om21
tun32_om22	tun32	om22	MP32	powerramp	all.idx	1500	270	0.1	1.42	0.85	1.2	MP32 / om22

Annexe 4 - h2 alternative recruitment robustness test om21 vs om22

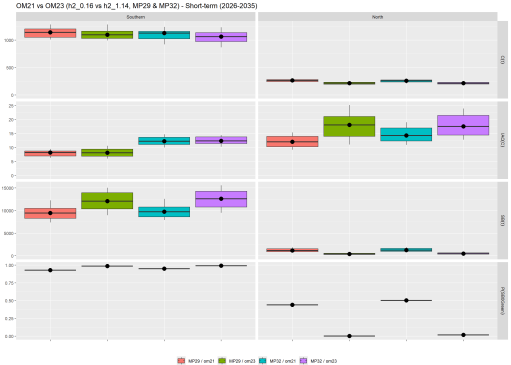


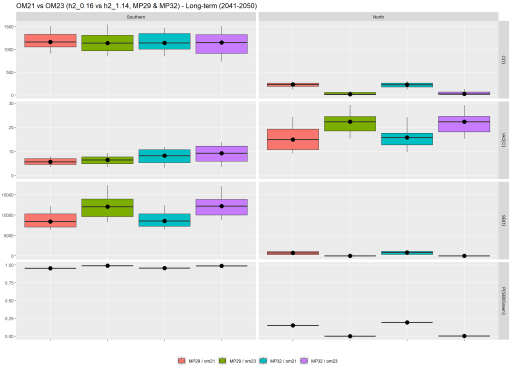


Annexe 5 - h2 model 1.14 robustness test om21 vs om23

run	mp	om	label	hcr	estimator	target	min	lim	trigger	dlow	dupp	label_plot
tun29_om21	tun29	om21	MP29	hockeystick.hcr	all.idx	2000	270	0.1	2.12	0.85	1.2	MP29 / om21
tun29_om23	tun29	om23	MP29	hockeystick.hcr	all.idx	2000	270	0.1	2.12	0.85	1.2	MP29 / om23
tun32_om21	tun32	om21	MP32	powerramp	all.idx	1500	270	0.1	1.42	0.85	1.2	MP32 / om21
tun32_om23	tun32	om23	MP32	powerramp	all.idx	1500	270	0.1	1.42	0.85	1.2	MP32 / om23

Annexe 5 - h2 model 1.14 robustness test om21 vs om23





Annexe 6a - MP control table (MP16–28)

MP	HCR	est	metric	target	min	lim	trig	slope
MP16	HS	all.idx	mean	2000	0	0.0	2.01	994
MP17	HS	all.idx	mean	3500	0	0.0	4.02	872
MP18	HS	all.idx	mean	5000	0	0.0	5.80	863
MP19	HS	all.idx	mean	1750	270	0.1	1.60	1090
MP20	HS	all.idx	mean	1750	270	0.2	1.57	1120
MP21	HS	all.idx	mean	2000	0	0.0	2.00	1000
MP22	PR	all.idx	mean	1500	270	0.0	1.41	NA
MP23	slope	all.idx	mean	NA	0	0.0	NA	822
MP24	HS	all.idx	mean	1750	0	0.0	1.51	1160
MP25	PR	all.idx	mean	1500	0	0.0	1.38	NA
MP26	PR	all.idx	mean	1750	0	0.0	1.70	NA
MP27	PR	all.idx	mean	2000	0	0.0	2.12	NA
MP28	PR	all.idx	mean	3500	0	0.0	3.67	NA

Annexe 6b - MP control table (MP29–42)

	MP	HCR	est	metric	target	min	lim	trig	slope
15	MP30	HS	all.idx	mean	2000	270	0.2	2.050	973
16	MP31	HS	all.idx	mean	2000	270	0.3	1.980	1010
17	MP32	PR	all.idx	mean	1500	270	0.1	1.420	NA
18	MP33	PR	all.idx	mean	1500	270	0.2	1.450	NA
19	MP34	PR	all.idx	mean	1500	270	0.3	1.470	NA
20	MP35	PR	all.cpue	mean	1500	270	0.1	1.490	NA
21	MP36	HS	all.cpue	mean	2000	270	0.1	2.220	901
22	MP37	PR	shortcut.sa	depletion	1500	270	0.1	0.341	NA
23	MP38	HS	shortcut.sa	depletion	2000	270	0.1	0.455	4400
24	MP39	PR	perfect.sa	depletion	1500	270	0.1	0.335	NA
25	MP40	HS	shortcut.sa	depletion	2000	270	0.1	0.463	4320
26	MP41	HS	all.idx	mean	2000	270	0.1	2.090	955
27	MP42	PR	all.idx	mean	1500	270	0.1	1.380	NA

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