IOTC-2022-WPTT24(DP)-19

AZTI

MEMBER OF
BASQUE RESEARCH
& TECHNOLOGY ALLIANCE

www.azti.es

Analysis of recruitment deviates of tropical tuna stock assessments

Options for a new diagnostic for ensembles of models

Merino, G., A. Urtizberea, D. Fu, H. Winker, M. Cardinale, M.V. Lauretta, H. Murua, T. Kitakado, H. Arrizabalagaa, R. Scott, G. Pilling, C. Minte-Vera, H. Xui, A. Laborda, M. Erauskin-Extraminiana, A. Uriarte, J. Santiago

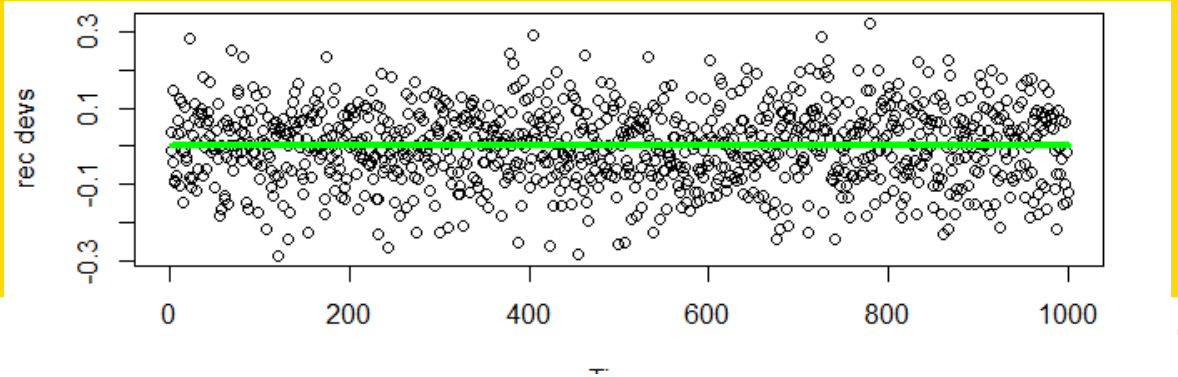
WPTT(DataPrepartory)-

Context in stock assessments (tropical tunas)

- Stocks productivity (life-history) determines response to fishing.
  - Data (C, CPUE, SFD...) vs underlying productivity.
  - Intrinsic factors (life history traits) vs extrinsic factors (fishing).
  - Productivity: Growth (fixed), M (fixed), steepness (fixed), R0 (free).
- Trends in abundance determined by productivity and recruitment deviates allow improving fits to variability of data).

Context in stock assessments (tropical tunas)

- Stocks productivity (life-history) determines response to fishing.
  - Data (C, CPUE, SFD...) vs underlying productivity.
  - Intrinsic factors (life history traits) vs extrinsic factors (fishing).
  - Productivity: Growth (fixed), M (fixed), steepness (fixed), R0 (free).
- Trends in abundance determined by productivity and recruitment deviates allow improving fits to variability of data).
- Ideal rec devs (process error) have no trends and maintain properties through time.



Context in stock assessments (tropical tunas)

- Stocks productivity (life-history) determines response to fishing.
  - Data (C, CPUE, SFD...) vs underlying productivity.
  - Intrinsic factors (life history traits) vs extrinsic factors (fishing).
  - Productivity: Growth (fixed), M (fixed), steepness (fixed), R0 (free).
- Trends in abundance determined by productivity and recruitment deviates allow improving fits to variability of data).
- Ideal rec devs (process error) have no trends and maintain properties through time.
- Tropical tuna SA using ensembles of models (combinations of assumptions, often biological).
- Diagnostics routinely incorporated in SA development (retro, hindcast, ... time consuming)
- Diagnostics often developed for base case only.

Objectives

- Explore trends in recruitment deviates and illustrate their links to hypotheses on productivity.
- Elucidate role of rec devs (variability or response to high catch).
- Develop a quick diagnostic to provide statistical support to hypotheses and assumptions in ensembles of models used to provide management advice.

Material and methods

- SS3 and Multifan-CL output from SA of tropical tunas (ICCAT, IOTC, IATTC and WCPFC).
  - Extract recruitment deviates and verify no-trend for each model of ensembles.
  - *No_trend* test from *funtimes* (Lyubichcich et al., 2022)*, Student's test, p-value (no linear trend).*

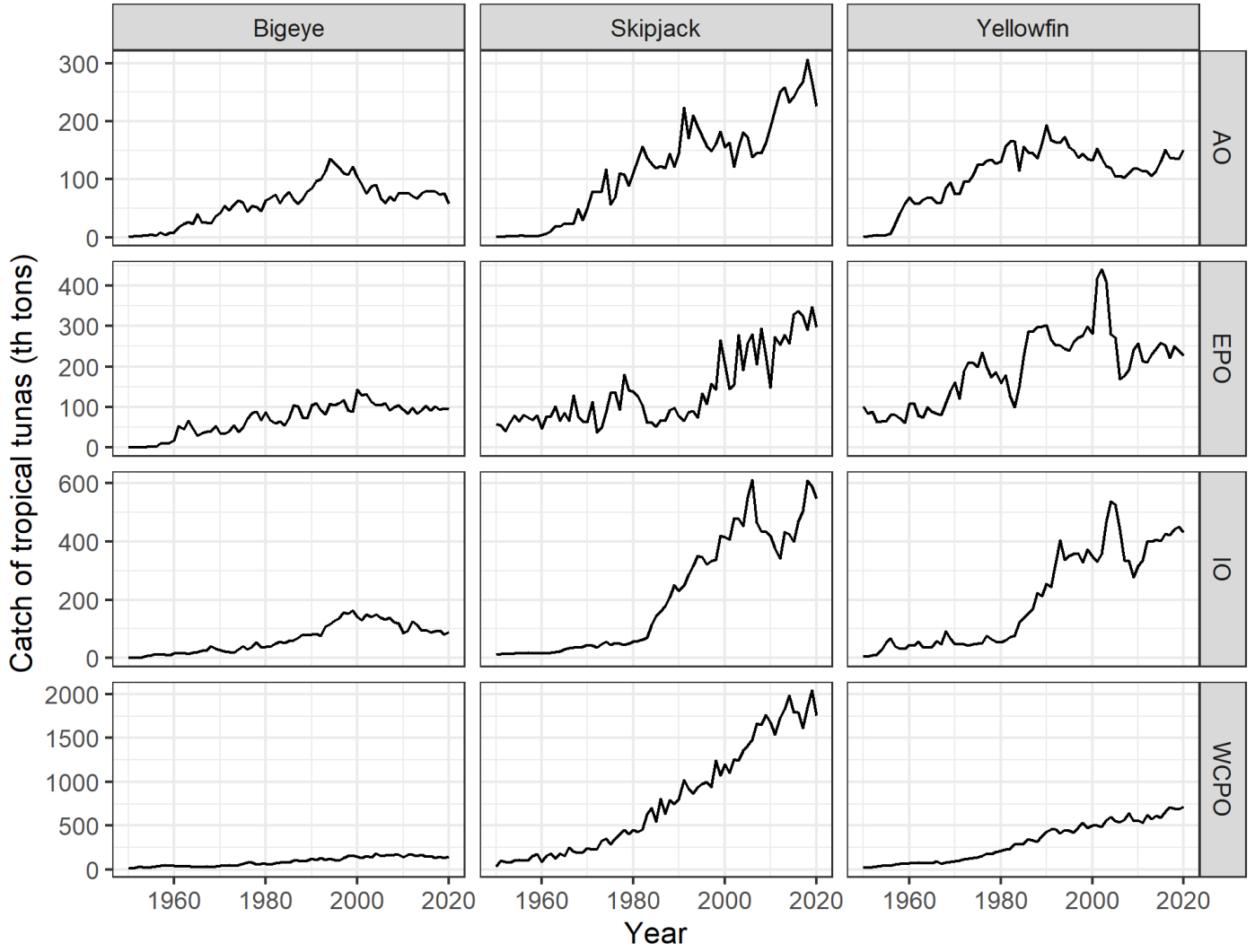
- Experiments on IO yellowfin stock assessment (Fu et al., 2021).
  - Ensemble of Steepness (h, 3), Growth (G, 2), Mortality (M, 2), Piracy (q, 2), Spatial (Io, Sp, 2), Tag (lambda, 2).
  - Run models without rec devs (Deactivate option in control files) and compare output (MSY, R0 and B/BMSY).
  - Produce bias in growth and mortality and carry out SA from simulated data (Dunn et al., 2020).
  - Compare p-value of *no_trend* test with other diagnostics (Carvalho et al., 2021).
    - ASPM, Mohn's rho, MASE and others.

AZTI
MEMBER OF
BASQUE RESEARCH
& TECHNOLOGY ALLIANCE

Results

(1) Catch history

- Tropical tuna fisheries developed with LL (~60s) and with PS (~80s).
- Peaks reached (1990-2010, second half).
- Some nearby historical maxima.



AZTI
MEMBER OF
BASQUE RESEARCH
& TECHNOLOGY ALLIANCE

Results

(2) Rec devs vs time

- Black (no trend, p >0.1)
- Blue (decreasing, p <0.1)
- Purple (increasing, p <0.1)

AZTI
MEMBER OF
BASQUE RESEARCH
& TECHNOLOGY ALLIANCE

Results

(2) Rec devs vs time

- Black (no trend, p >0.1)
- Blue (decreasing, p <0.1)
- Purple (increasing, p <0.1)

AZTI
MEMBER OF
BASQUE RESEARCH
& TECHNOLOGY ALLIANCE

Results

(2) Rec devs vs time

- Black (no trend, p >0.1)
- Blue (decreasing, p <0.1)
- Purple (increasing, p <0.1)

Evidence of rec dev trends

- Role of rec devs?

Variability vs response to catch

Results

(3) Rec devs vs MSY

- Black (no trend, p >0.1)
- Blue (decreasing, p <0.1)
- Purple (increasing, p <0.1)

Evidence of rec dev trends

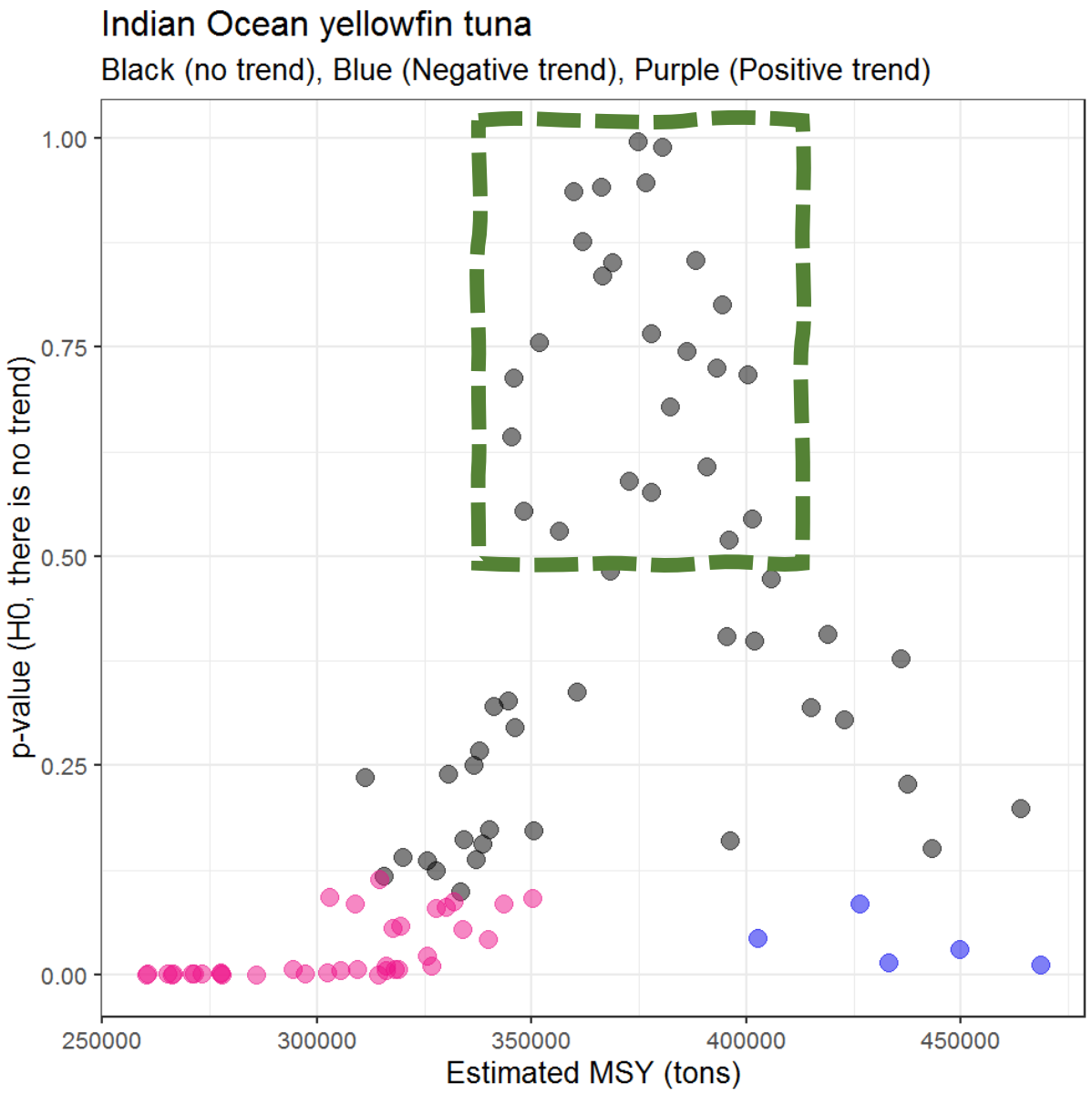
- Role of rec devs?

<u>Variability vs response to catch</u>

Upper range of MSY

Lower range of MSY

Middle range of MSY



- **Average [1992-2020] = 382 th tons.**
- **Average [2000-2020] = 401 th tons.**
- **Sustainable without rec devs?**

Results

(3) Rec devs vs MSY

- Black (no trend, p >0.1)
- Blue (decreasing, p <0.1)
- Purple (increasing, p <0.1)

Evidence of rec dev trends

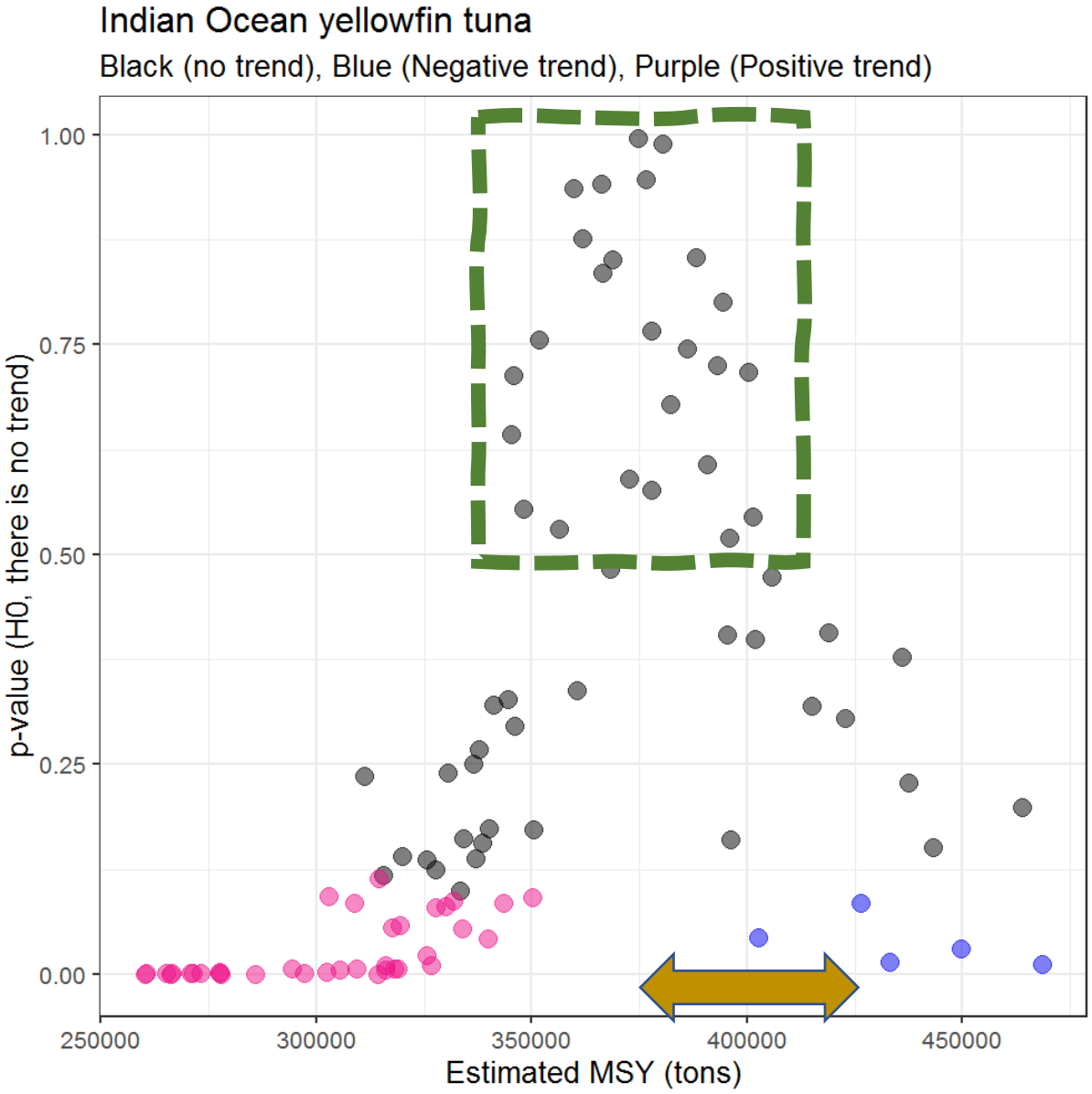
- Role of rec devs?

Variability vs response to catch

Upper range of MSY

Lower range of MSY

Middle range of MSY



Results

(4) Rec devs vs difference with/without devs (MSY)

- Black (no trend, p >0.1)
- Blue (decreasing, p <0.1)
- Purple (increasing, p <0.1)

Evidence of rec dev trends

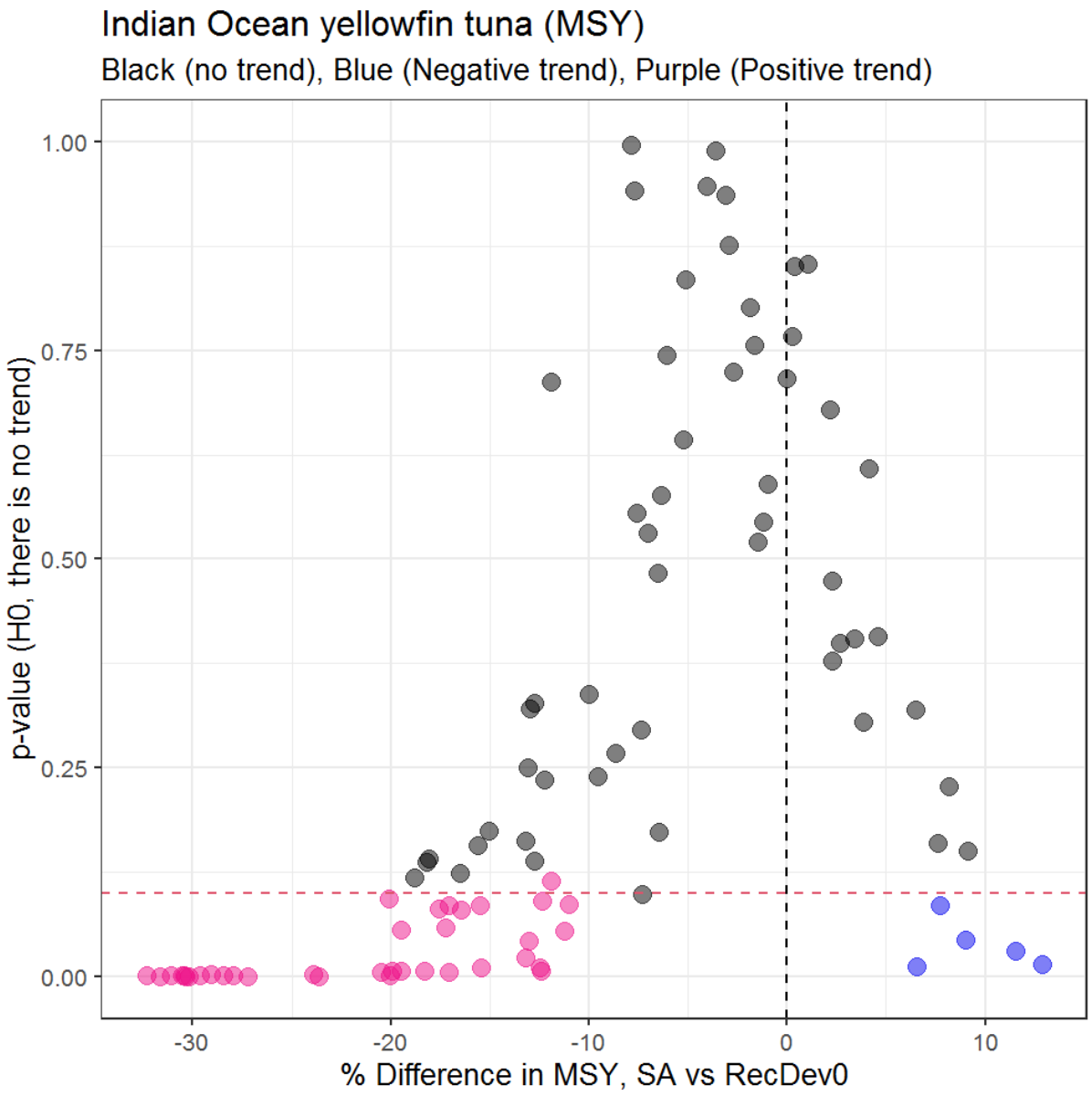
- Role of rec devs?

<u>Variability vs response to catch</u>

Upper range of MSY ⟶ $MSY_{SA} > MSY_{RecDev0}$

Lower range of MSY ⟶ $MSY_{SA} < MSY_{RecDev0}$

Middle range of MSY ⟶ $MSY_{SA} \sim MSY_{RecDev0}$



Fixed M, G, h -> increase R0 if it needs to fit data with underlying productivity (RecDev0). With rec devs these can be used to respond to high catch instead of underlying productivity (SA).

Results

(4) Rec devs vs difference with/without devs (R0)

- Black (no trend, p >0.1)
- Blue (decreasing, p <0.1)
- Purple (increasing, p <0.1)

Evidence of rec dev trends

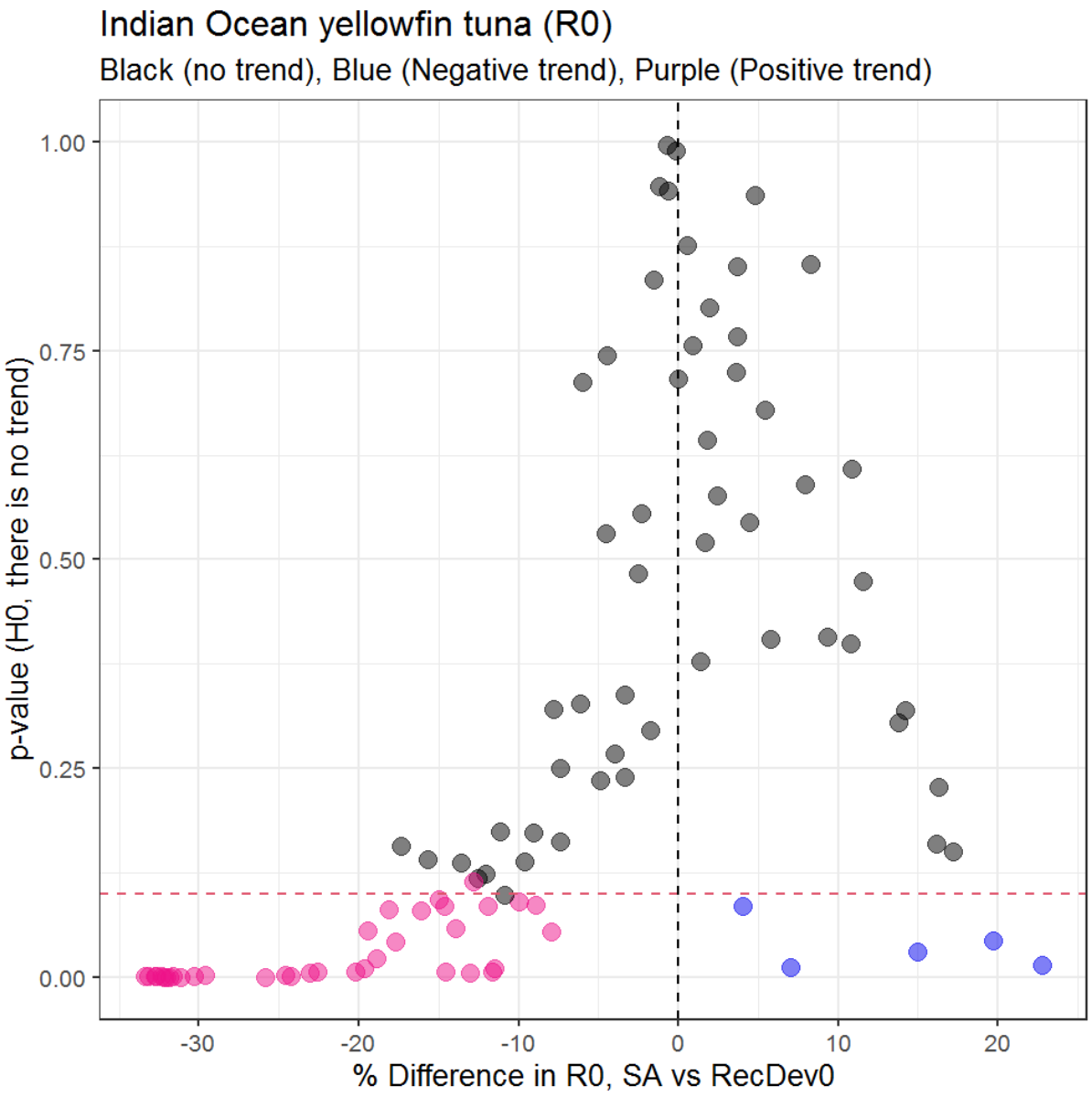
- Role of rec devs?

<u>Variability vs response to catch</u>

Upper range of MSY ⟶ $R0_{SA} > R0_{RecDev0}$

Lower range of MSY ⟶ $R0_{SA} < R0_{RecDev0}$

Middle range of MSY ⟶ $R0_{SA} \sim R0_{RecDev0}$



AZTI
MEMBER OF
BASQUE RESEARCH
& TECHNOLOGY ALLIANCE

Fixed M, G, h -> increase R0 if it needs to fit data with underlying productivity (RecDev0). With rec devs these can be used to respond to high catch instead of underlying productivity (SA).

Results

(4) Rec devs vs difference with/without devs (B/B_{msy})

- Black (no trend, p >0.1)
- Blue (decreasing, p <0.1)
- Purple (increasing, p <0.1)

Evidence of rec dev trends

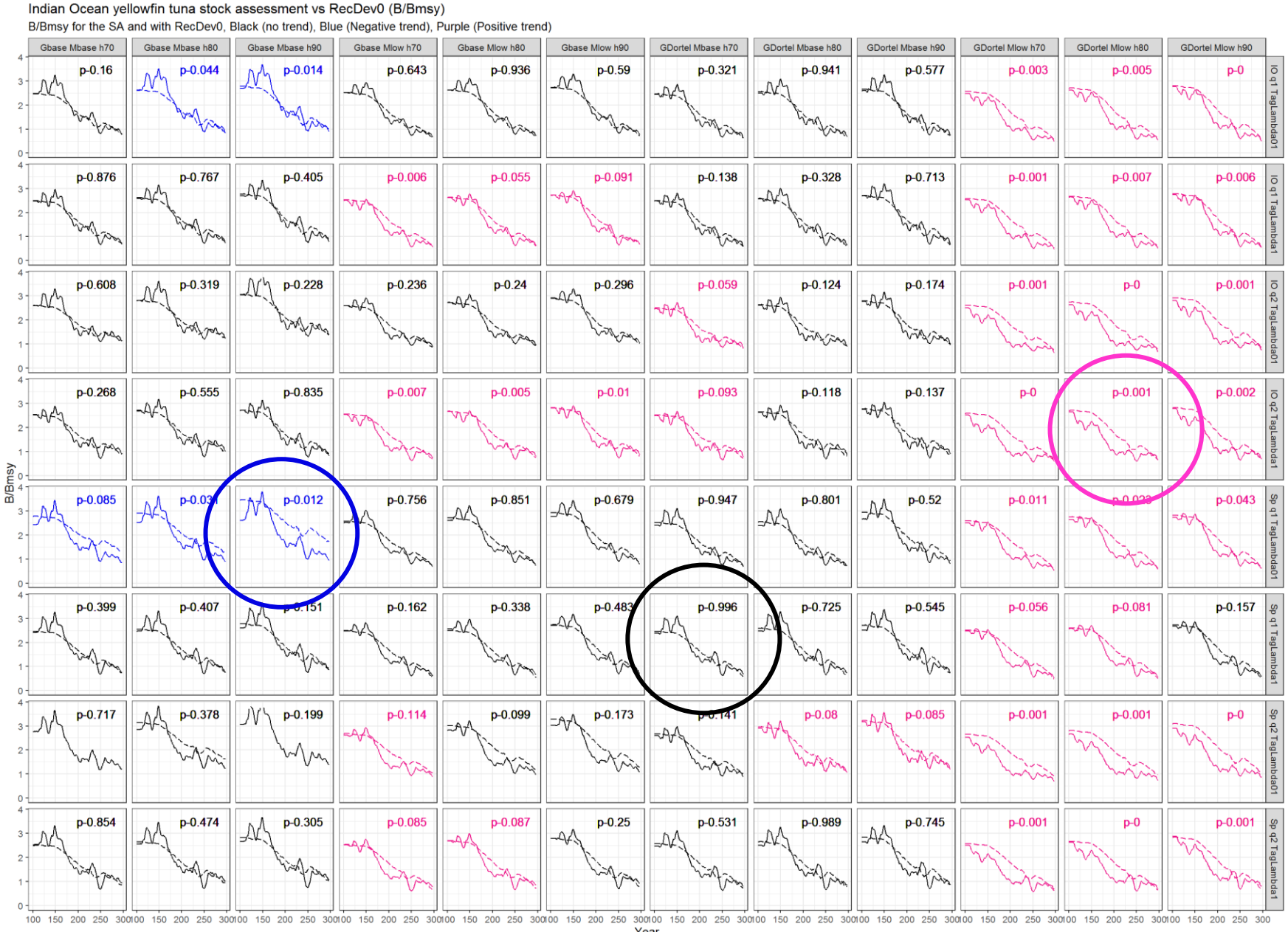
- Role of rec devs?

<u>Variability vs response to catch</u>

Comparable trends

Comparable status terminal year, very different throghout.

Larger B/Bmsy (RecDev0) ty and throughout.



Fixed M, G, h -> increase R0 if it needs to fit data with underlying productivity (RecDev0). With rec devs these can be used to respond to high catch instead of underlying productivity (SA).

Results

(4) Rec devs vs difference with/without devs (B/B_{msy})

- Black (no trend, p >0.1)
- Blue (decreasing, p <0.1)
- Purple (increasing, p <0.1)

Evidence of rec dev trends

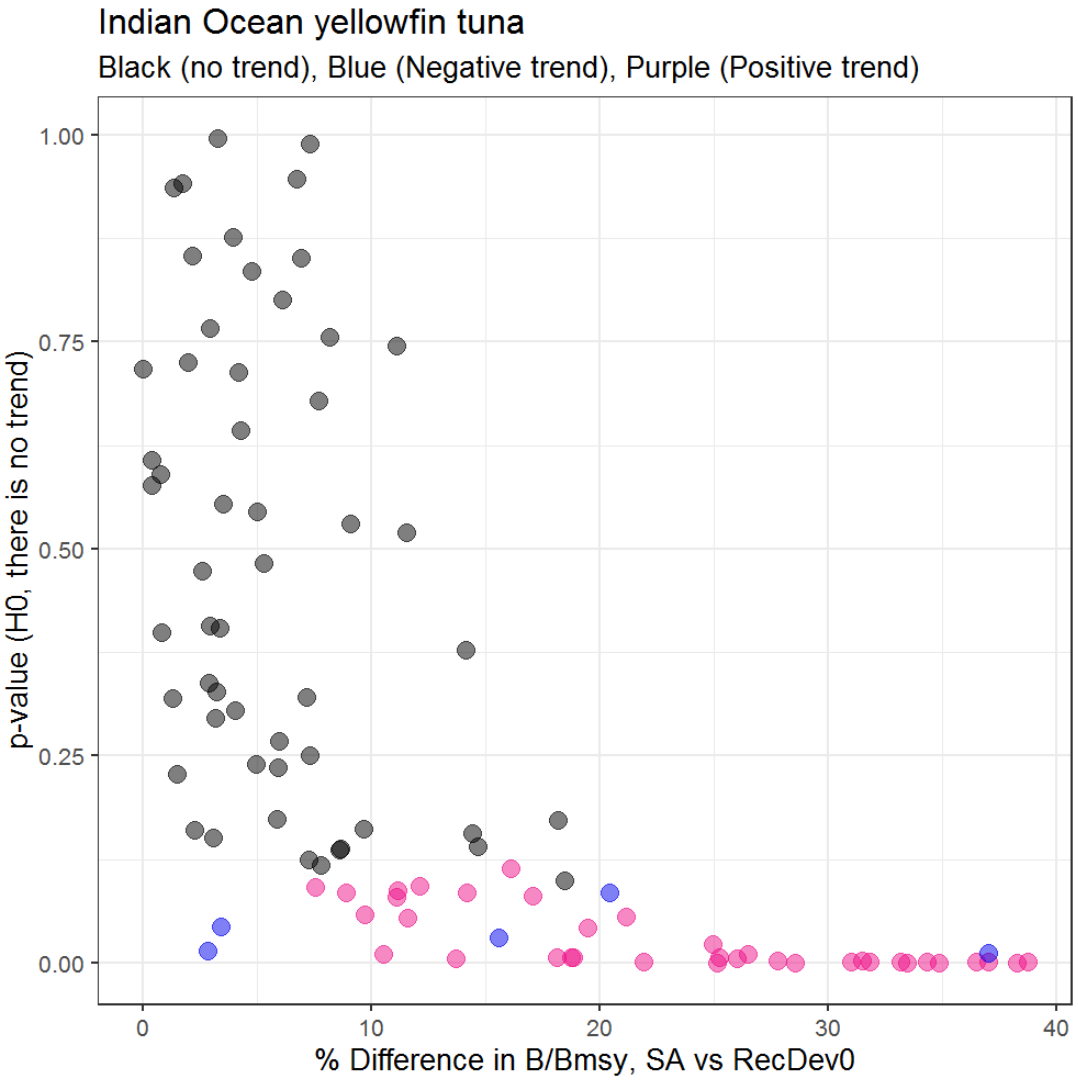
- Role of rec devs?

<u>Variability vs response to catch</u>

Comparable trends

Comparable status terminal year, very different throghout.

Larger B/Bmsy (RecDev0) ty and throughout.



Results

(5) Rec devs in simulated model (Dunn et al, 2020). Extract data with error from OM using two growth curves (as in OM and Dortel) and a range of biased natural mortality (M050=M50% lower than M100 and M150=50% larger than M100, M100=M from OM).

AZTI
MEMBER OF
BASQUE RESEARCH
& TECHNOLOGY ALLIANCE

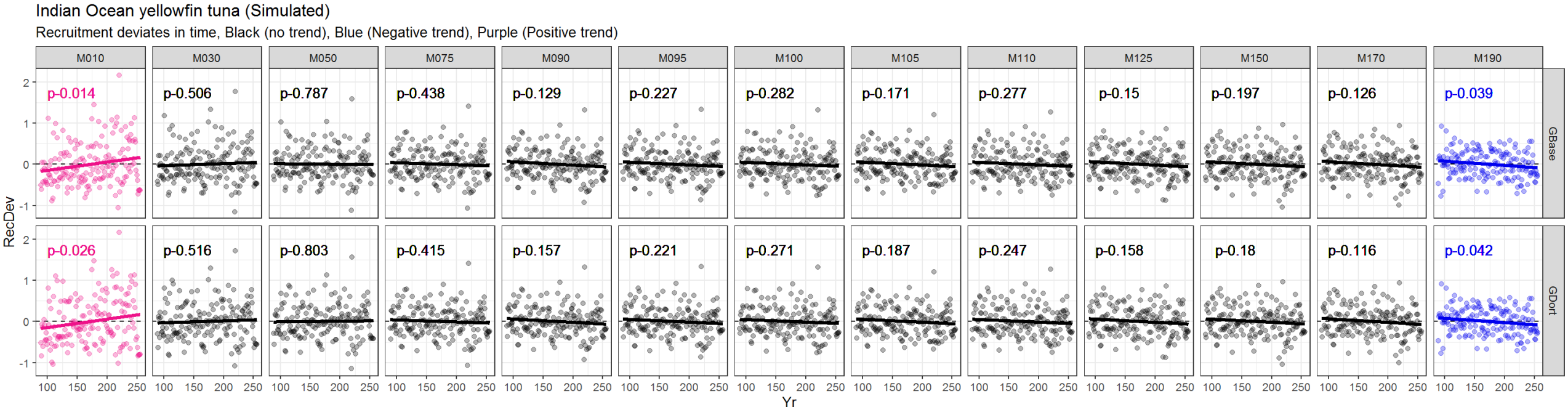
Evidence of rec dev trends
Bias in assumptions?

Results

- Positive and negative trends with extreme bias only (±90%).

(5) Rec devs in simulated model (Dunn et al, 2020). Extract data with error from OM using two growth curves (as in OM and Dortel) and a range of biased natural mortality (M050=M50% lower than M100 and M150=50% larger than M100, M100=M from OM).

- Black (no trend, p >0.1)
- Blue (decreasing, p <0.1)
- Purple (increasing, p <0.1)



Evidence of rec dev trends

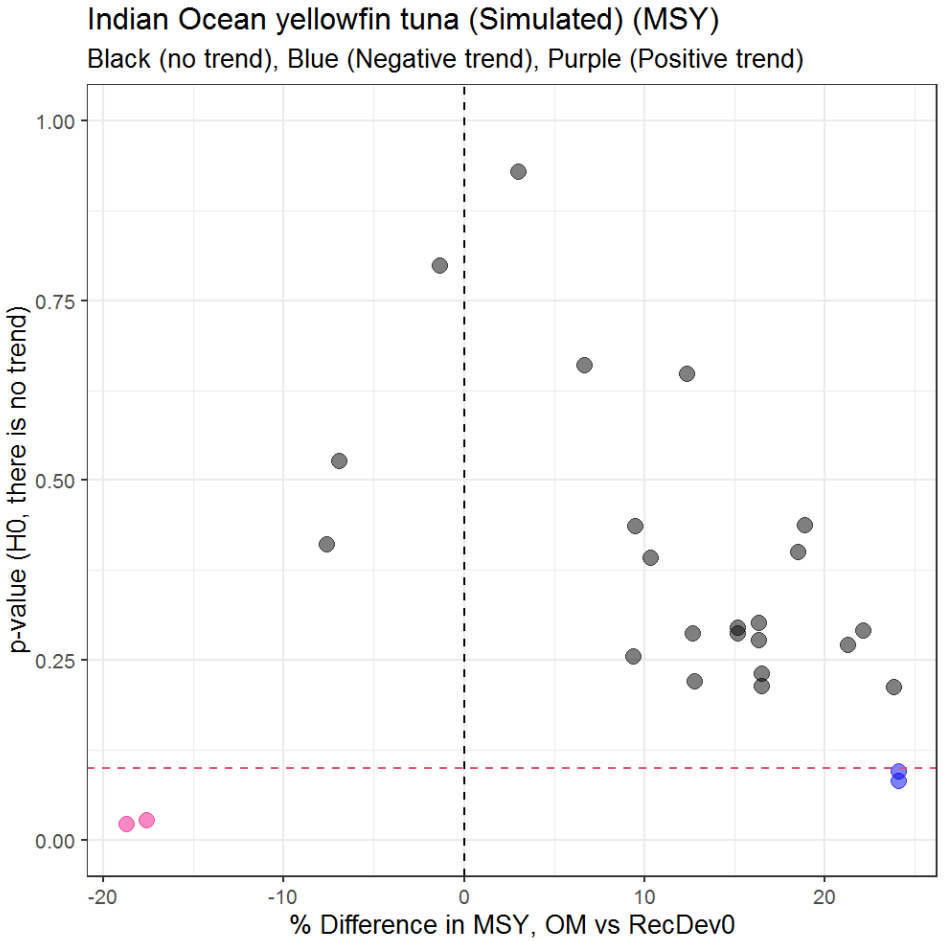
Bias in assumptions?

Results

- Positive and negative trends with extreme bias only (±90%).
- As expected, lower M -> lower MSY **->** Increasing trends and likewise higher M.

(5) Rec devs in simulated model (Dunn et al, 2020).

- Black (no trend, p >0.1)
- Blue (decreasing, p <0.1)
- Purple (increasing, p <0.1)



Evidence of rec dev trends

Bias in assumptions? **Incompatibility of assumptions and data conflict?**

Results

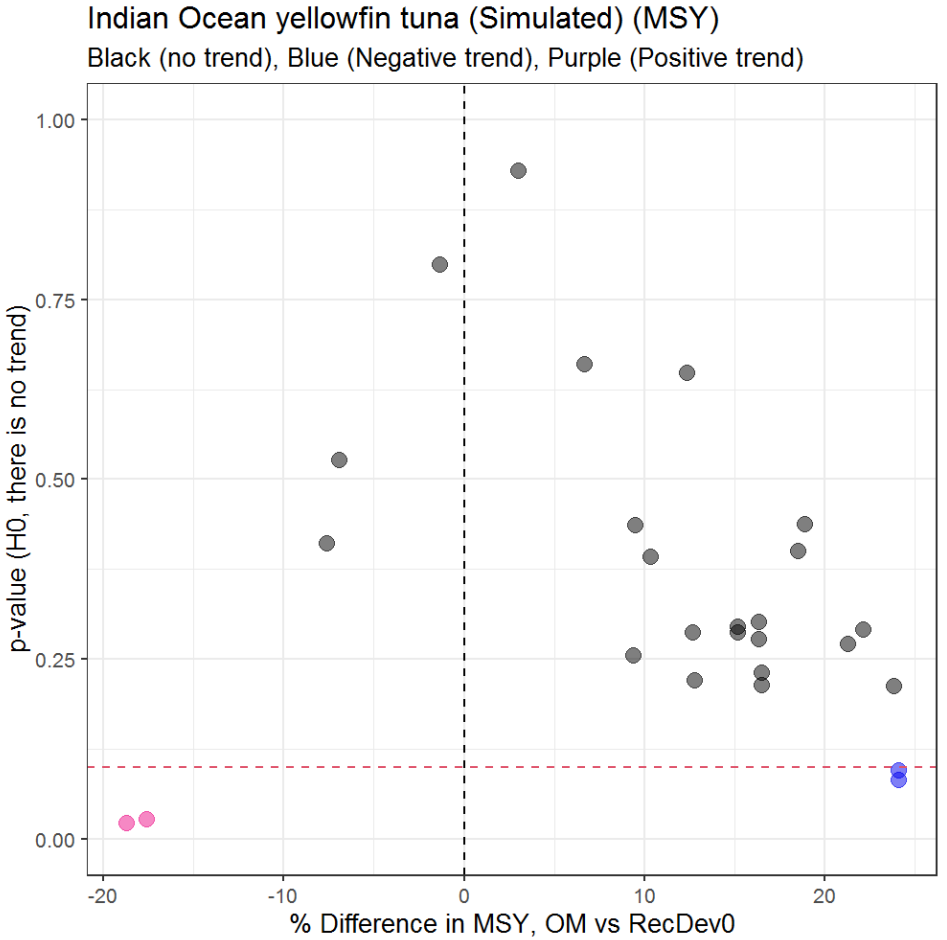
- Positive and negative trends with extreme bias only (±90%).
- As expected, lower M -> lower MSY **->** Increasing trends and likewise higher M.

(5) Rec devs in simulated model (Dunn et al, 2020).

- Black (no trend, p >0.1)
- Blue (decreasing, p <0.1)
- Purple (increasing, p <0.1)

Why only in extreme bias?

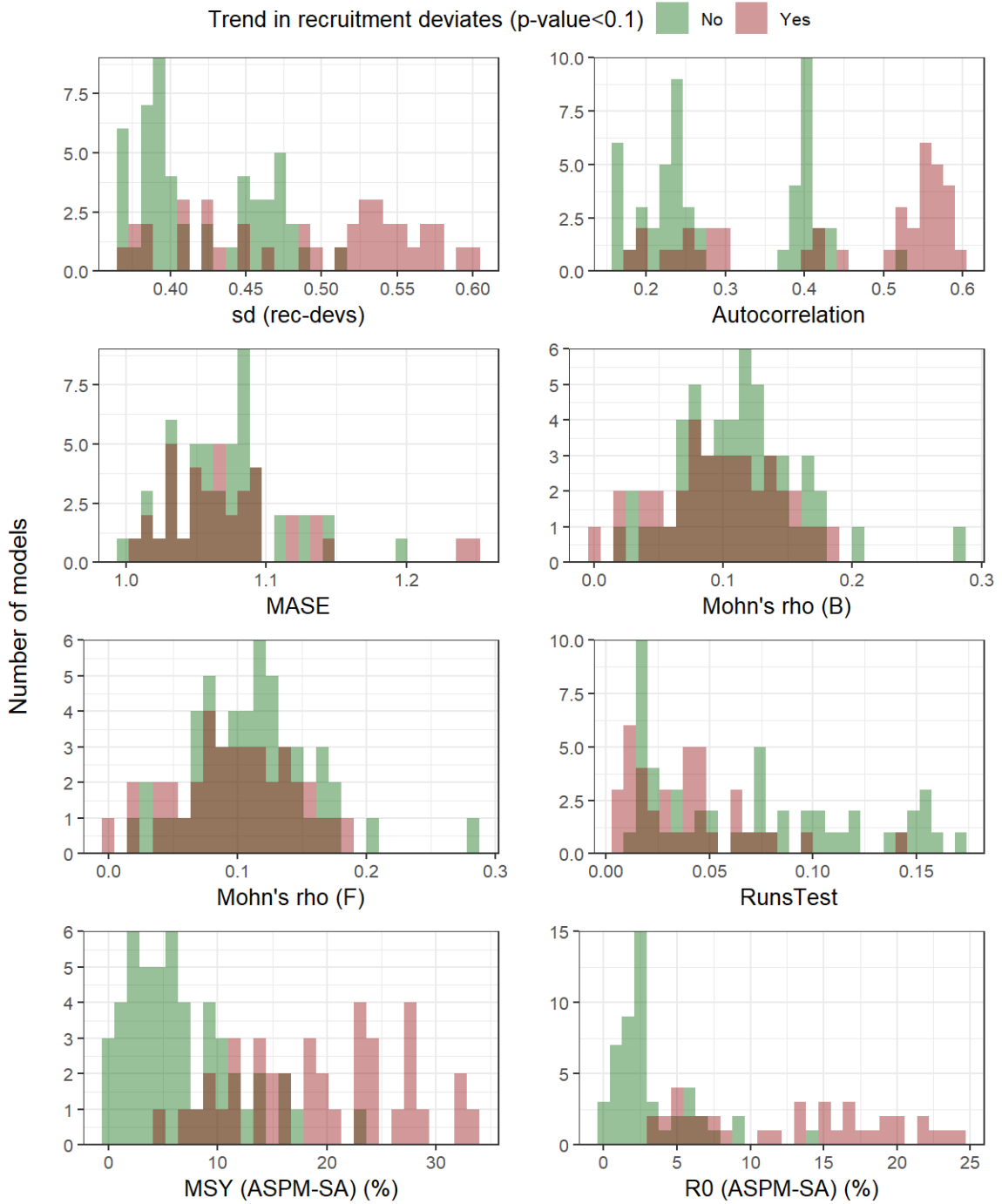
- Good consistency between catch, CPUE, Tags and SFD in OM ≠ SA.
- IO yft SA disaggregated and trends in regional distribution also identified which suggests additional problems that do not affect the OM.



MEMBER OF
BASQUE RESEARCH
& TECHNOLOGY ALLIANCE

Results

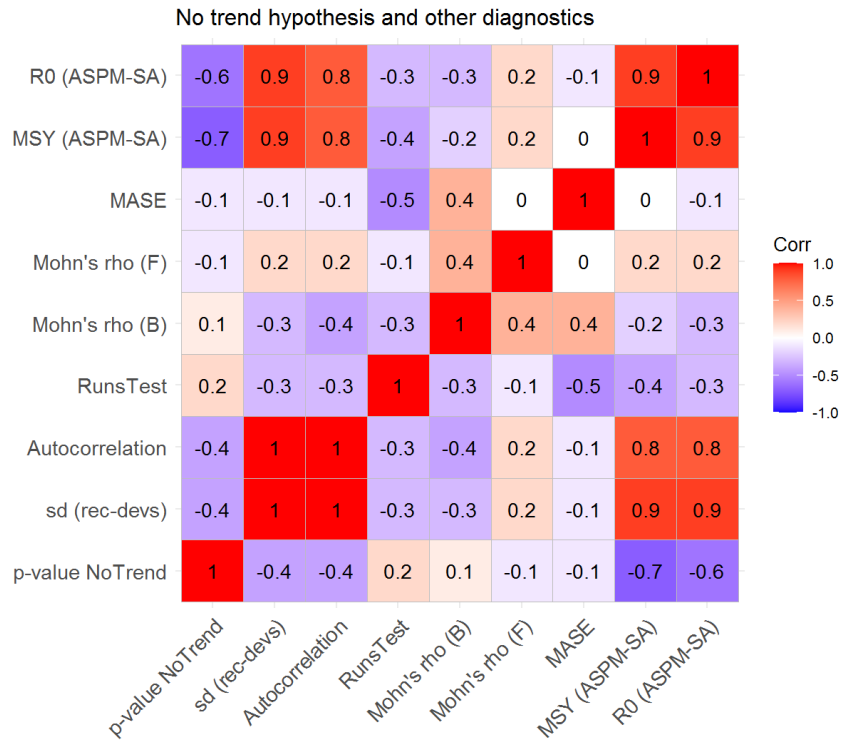
(6) Consistency with other diagnostics

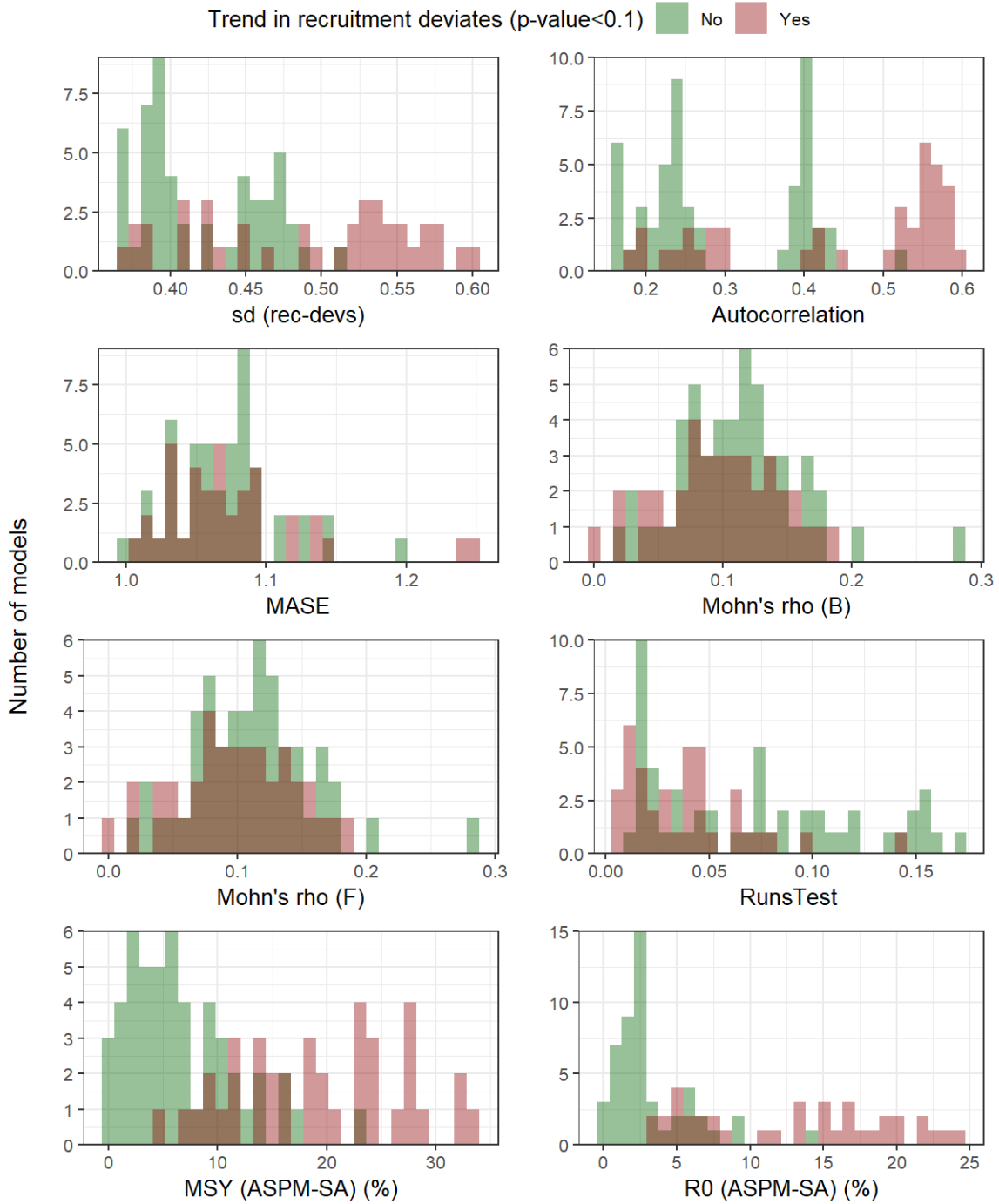


AZTI
MEMBER OF
BASQUE RESEARCH
& TECHNOLOGY ALLIANCE

Results

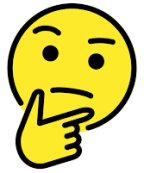
(6) Consistency with other diagnostics



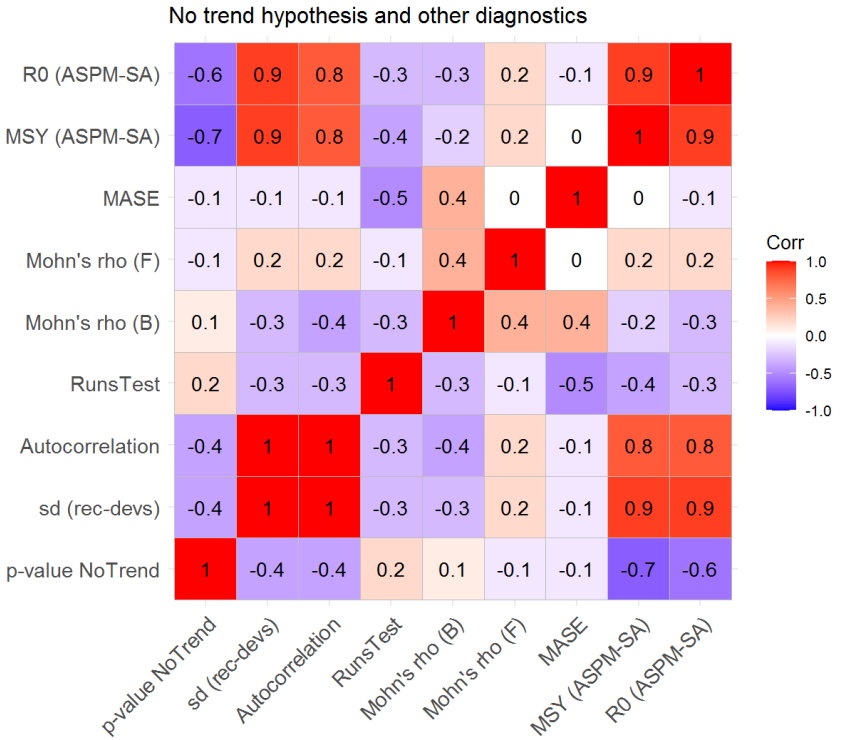


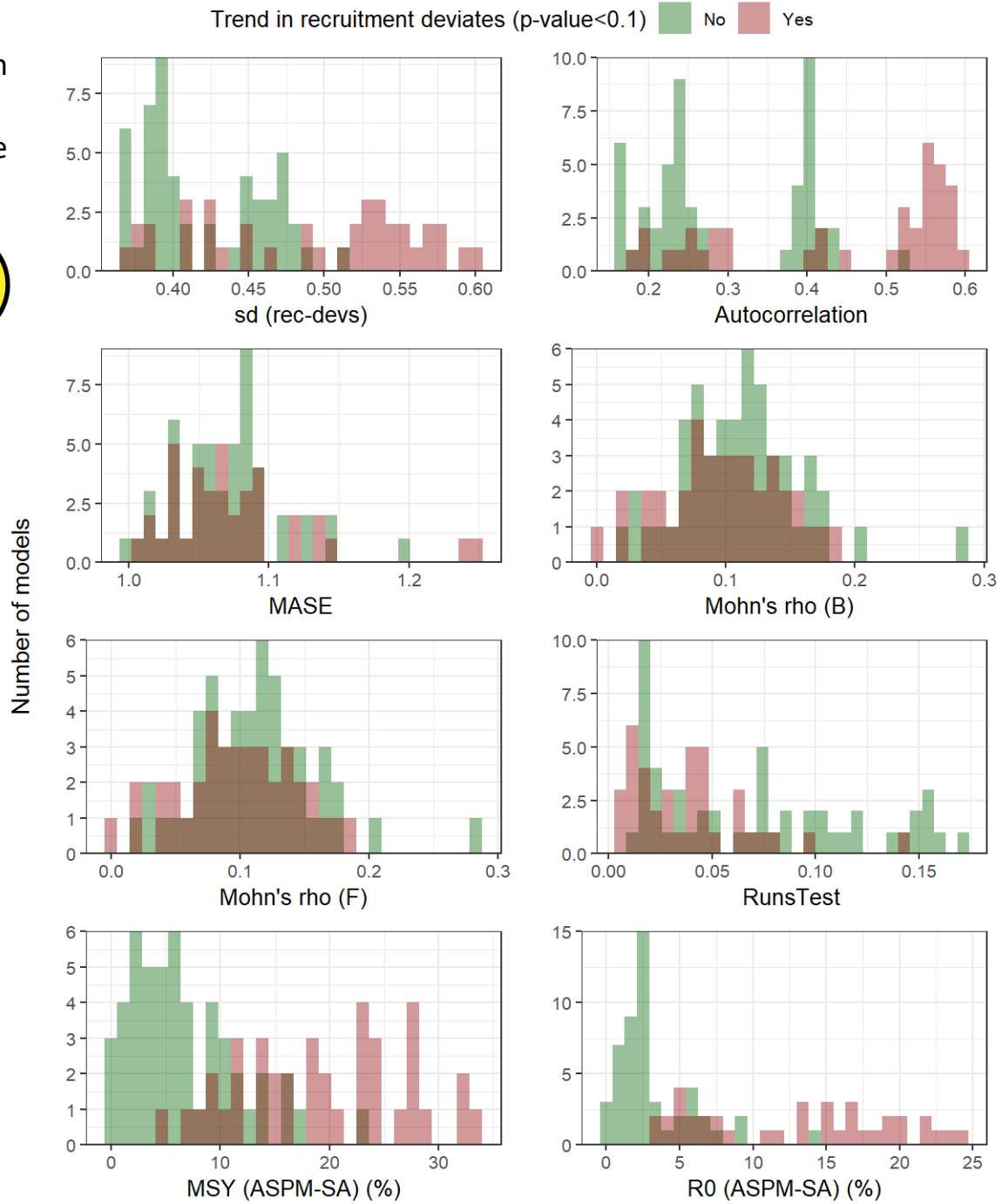
- How to use diagnostics to assign plausibility to models in ensembles (Maunder, 2020).
- Some diagnostics are time consuming, the p-value of the no-trend for rec devs is estimated in seconds.

Results



(6) Consistency with other diagnostics





Management implications

- Plausibility of models when advice developed from ensembles of models (Maunder et al 2020):

Management implications

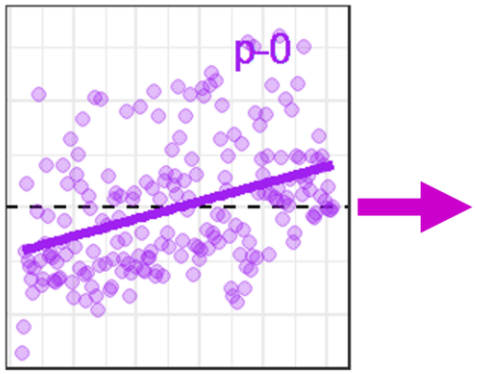
- Plausibility of models when advice developed from ensembles of models (Maunder et al 2020):
  - ✓ Statistical support to assumptions (combinations of hypotheses and not individual factors)
  - ✓ Compatibility of assumptions and data.

Management implications

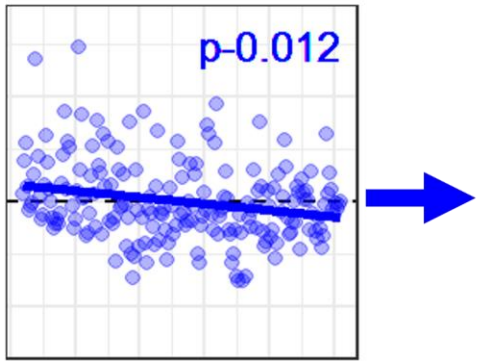
- Plausibility of models when advice developed from ensembles of models (Maunder et al 2020):
  - ✓ Statistical support to assumptions (combinations of hypotheses and not individual factors)
  - ✓ Compatibility of assumptions and data.

- Catch advice -> Projections with rec deviates to reduce uncertainty.

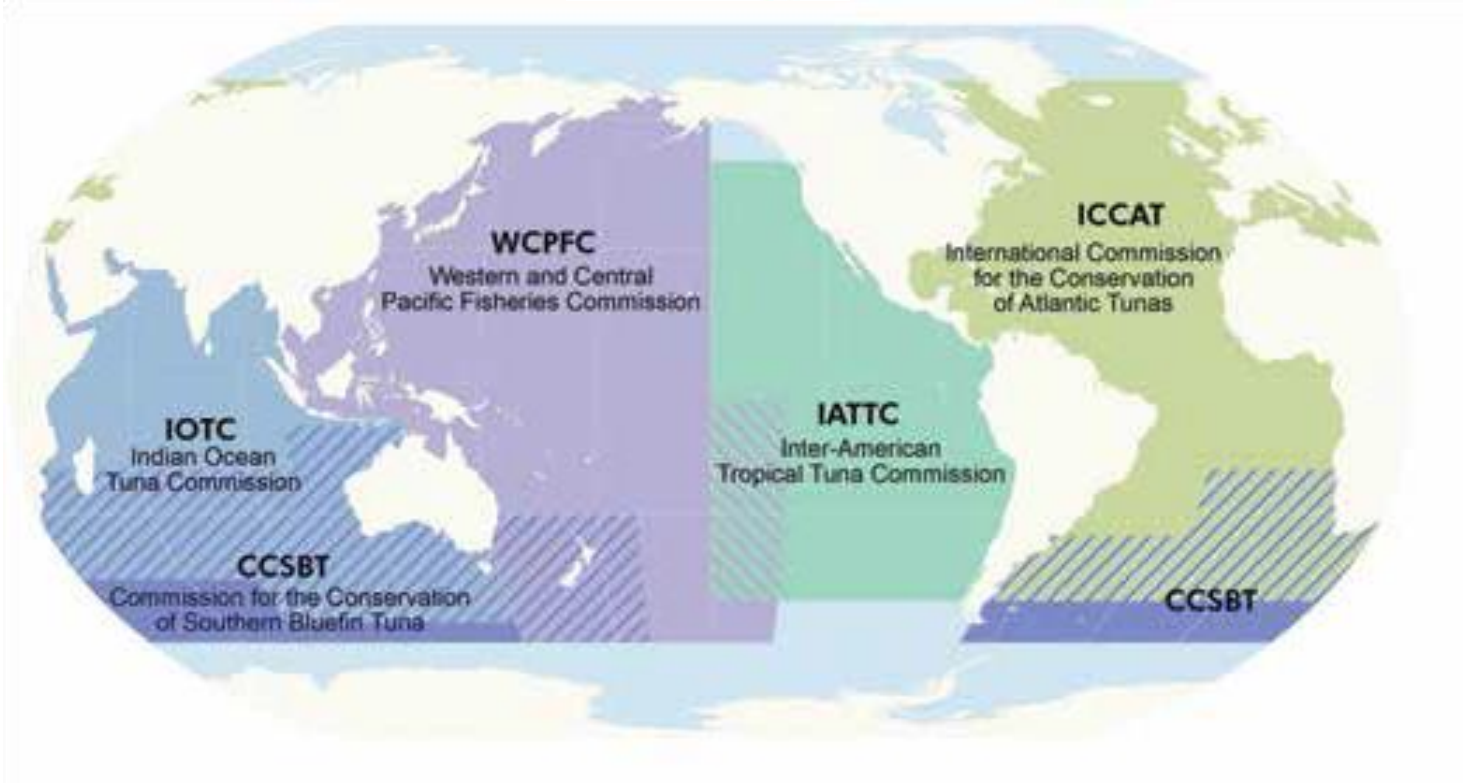
Increasing, p <0.1 → Collapse



Decreasing, p <0.1 → Boom



Results (Other tropical tunas' SA)

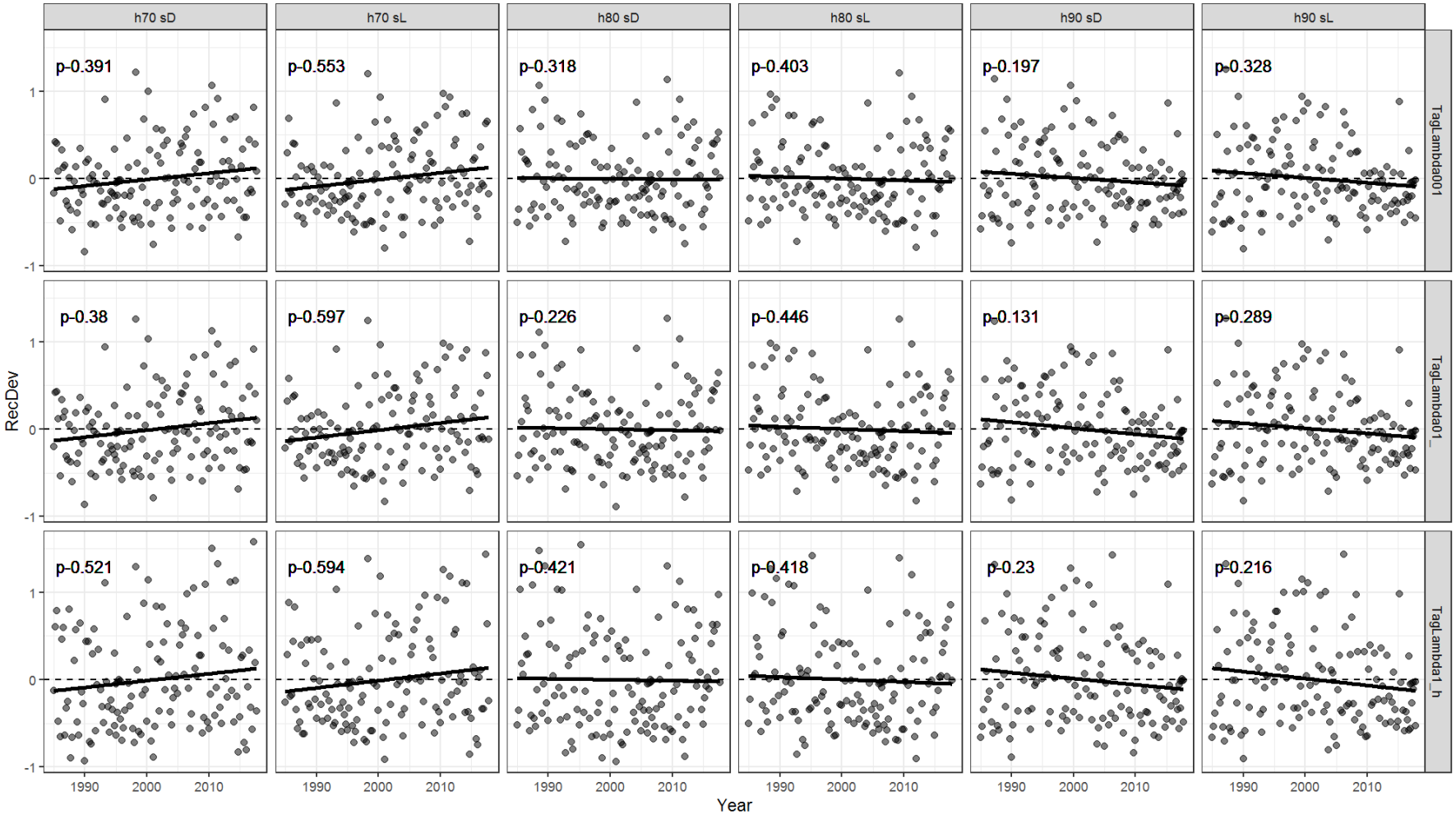


Results (Other tropical tunas' SA)

IO Bigeye

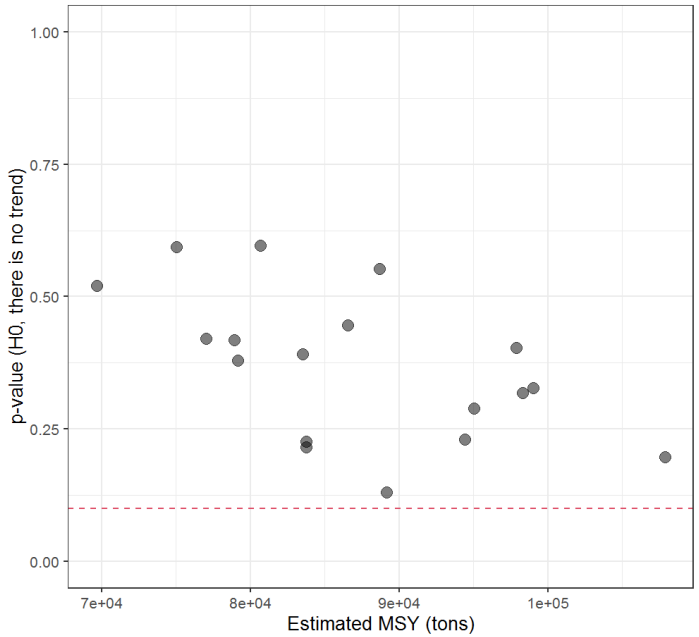
Indian Ocean bigeye tuna

Recruitment deviates in time, Black (no trend), Blue (Negative trend), Purple (Positive trend)



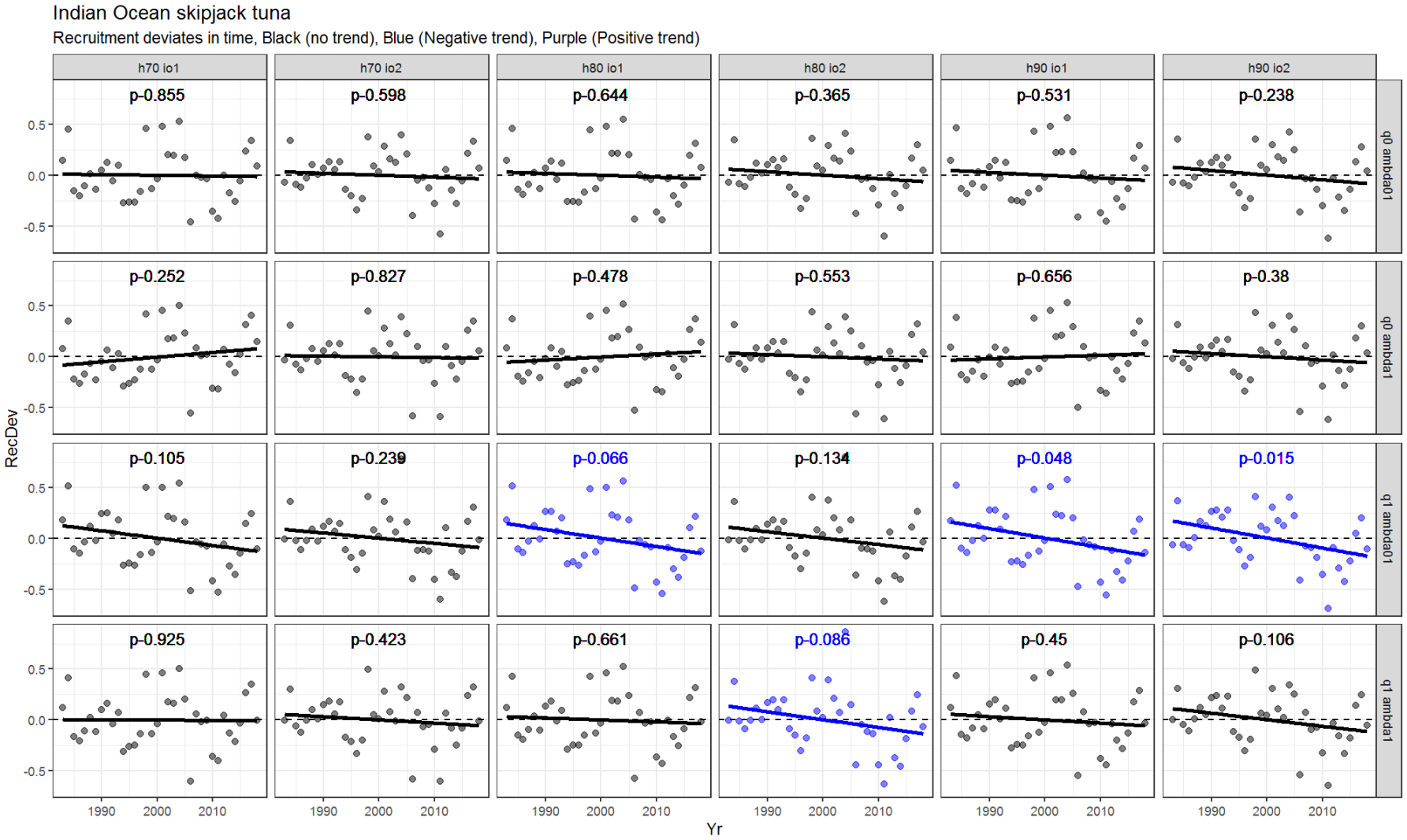
Indian Ocean bigeye tuna

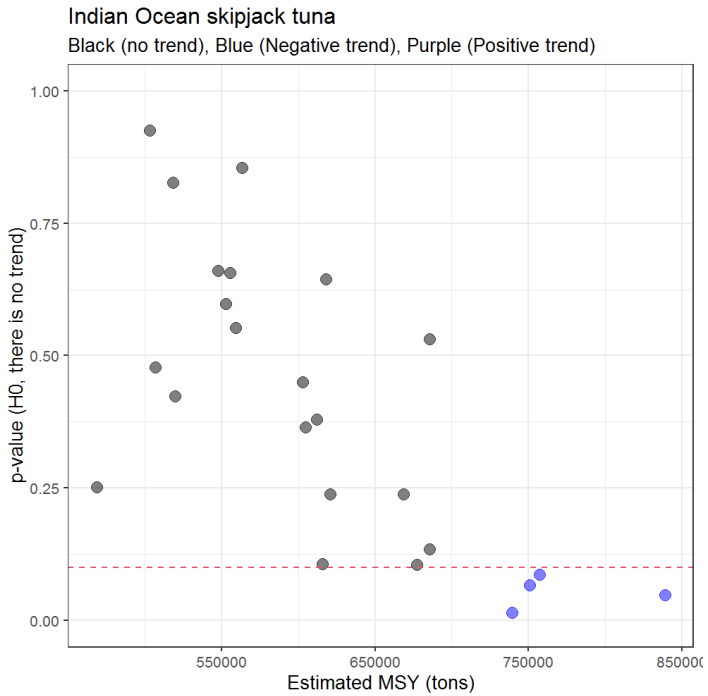
Black (no trend), Blue (Negative trend), Purple (Positive trend)



Results (Other tropical tunas' SA)

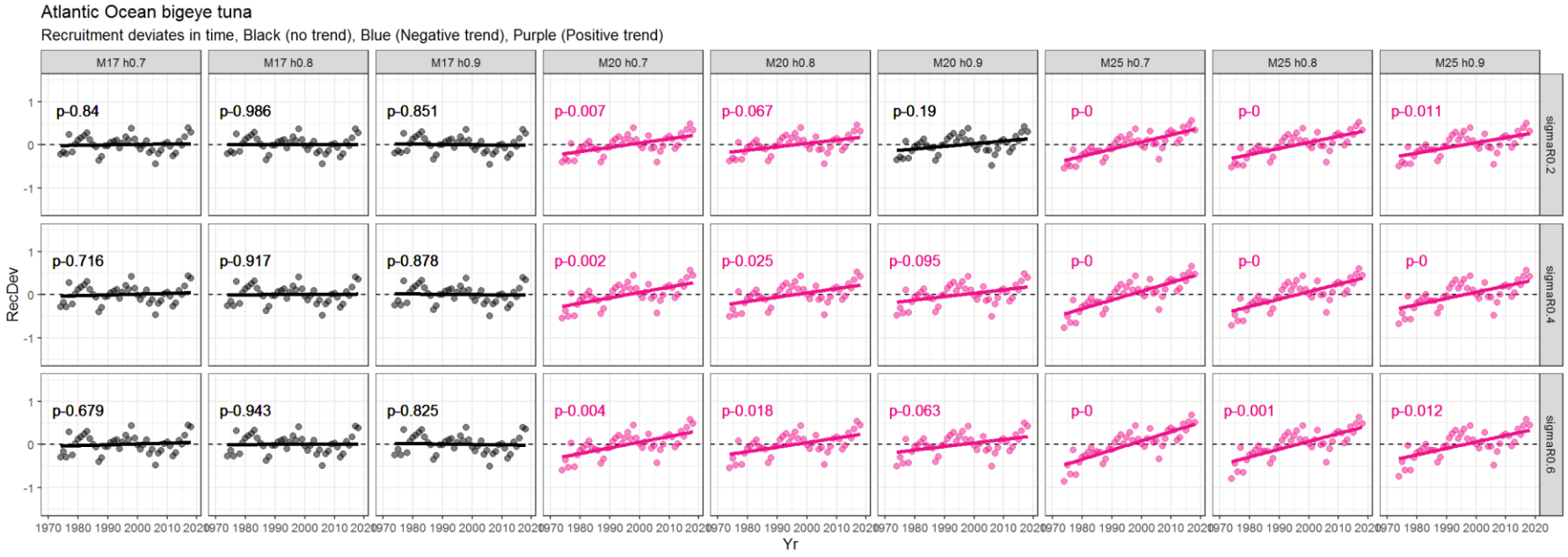
IO Skipjack

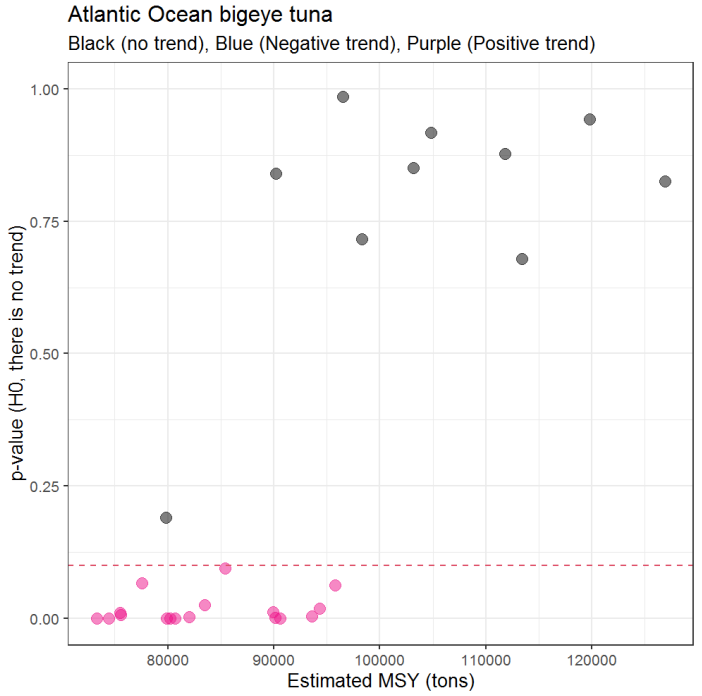




Results (Other tropical tunas' SA)

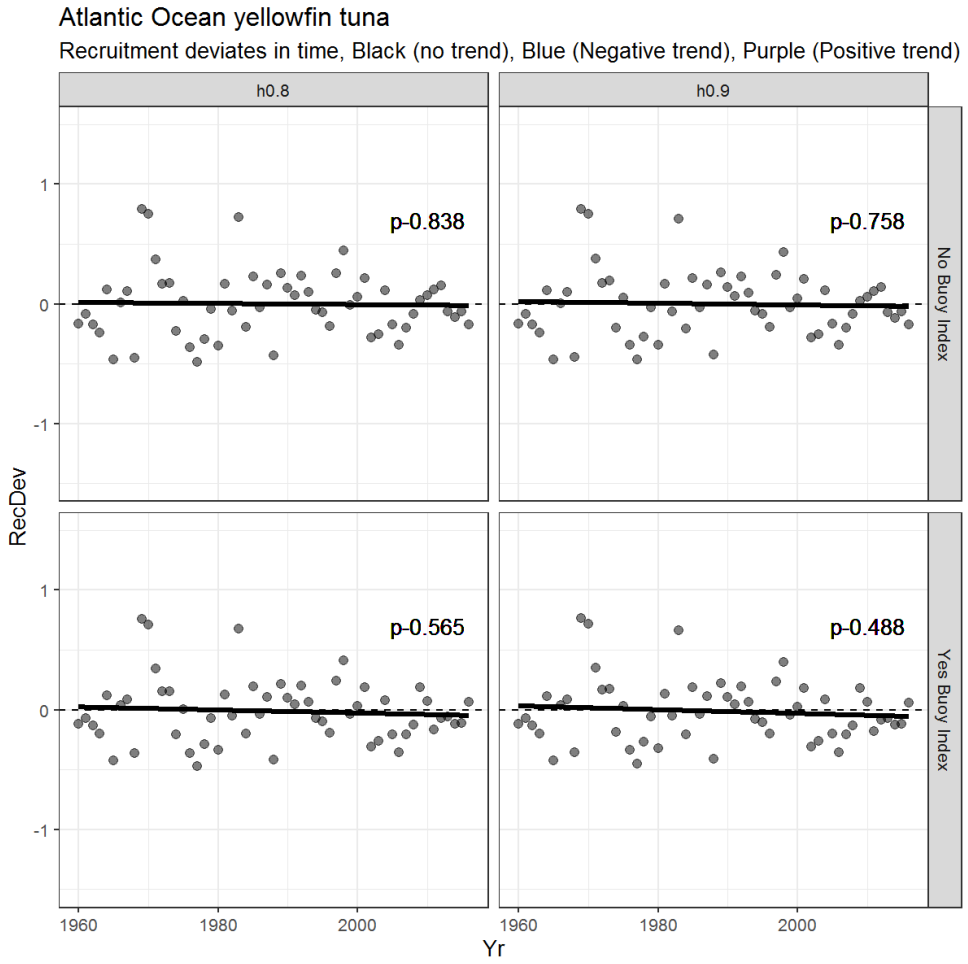
AO Bigeye

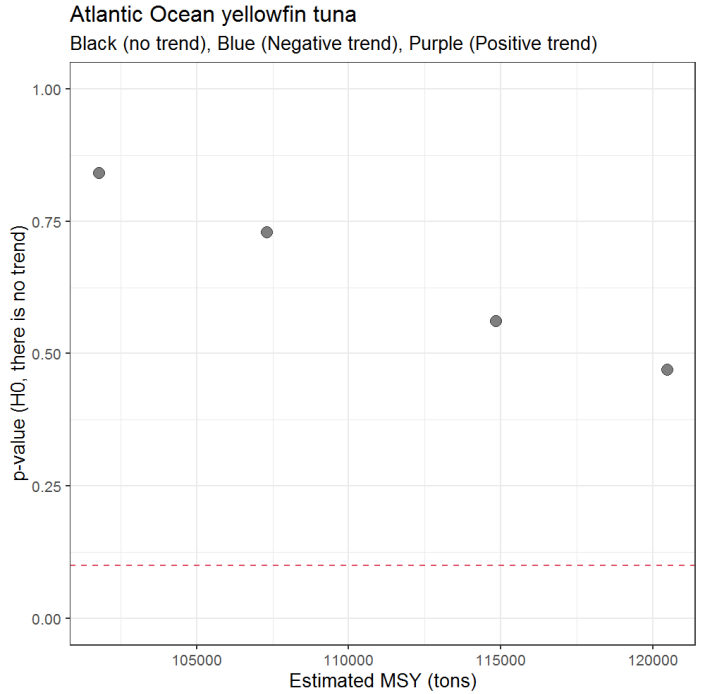




Results (Other tropical tunas' SA)

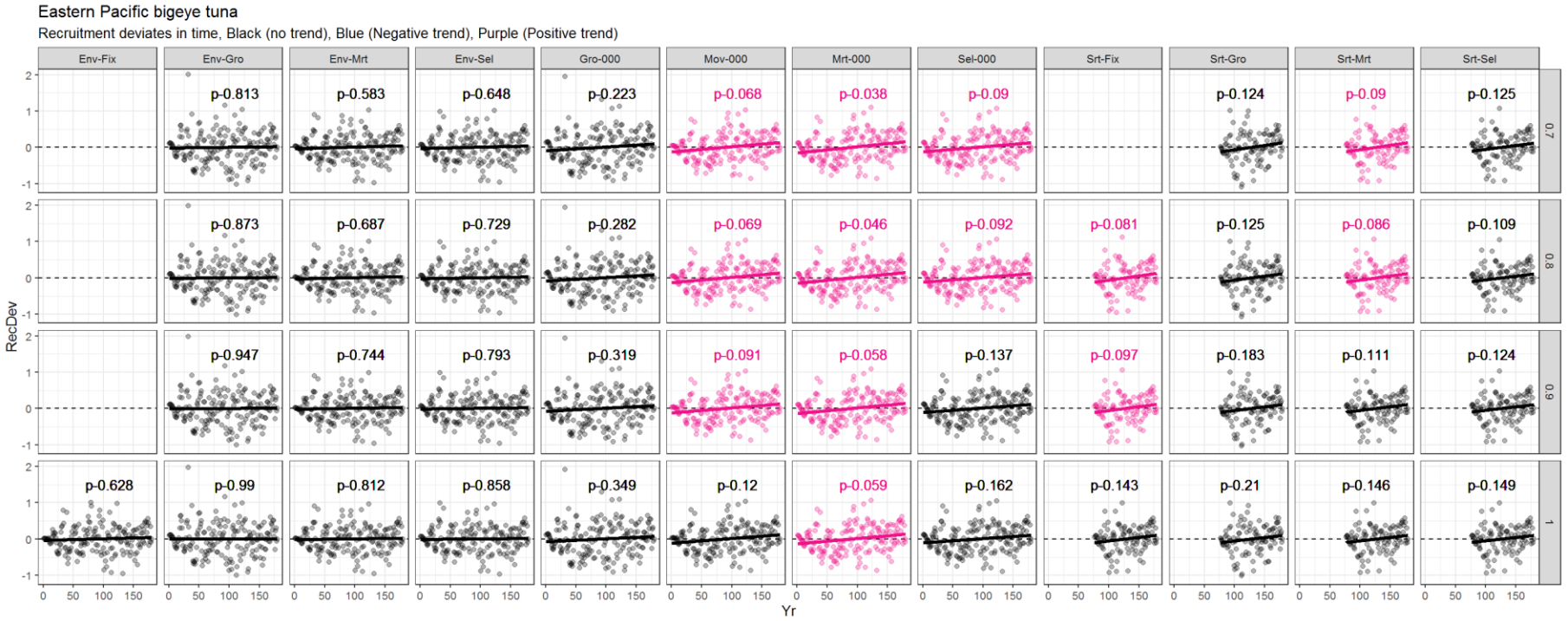
AO Yellowfin

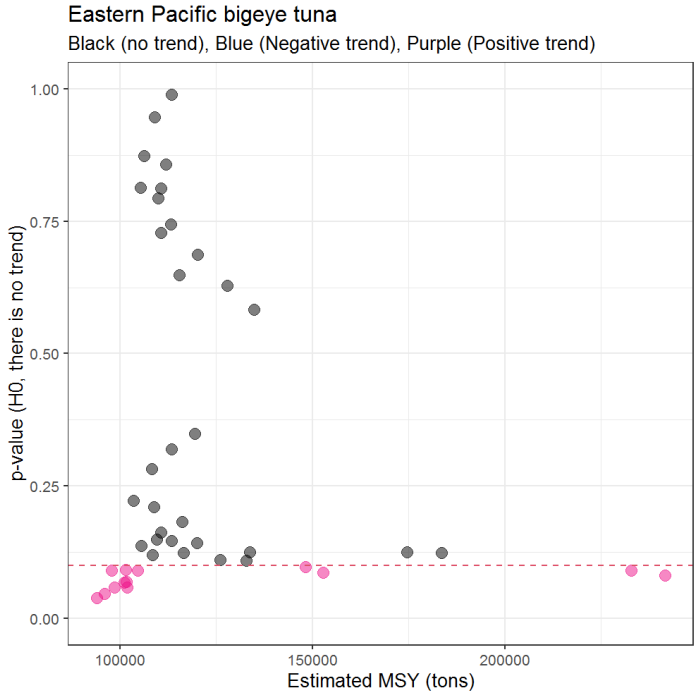




Results (Other tropical tunas' SA)

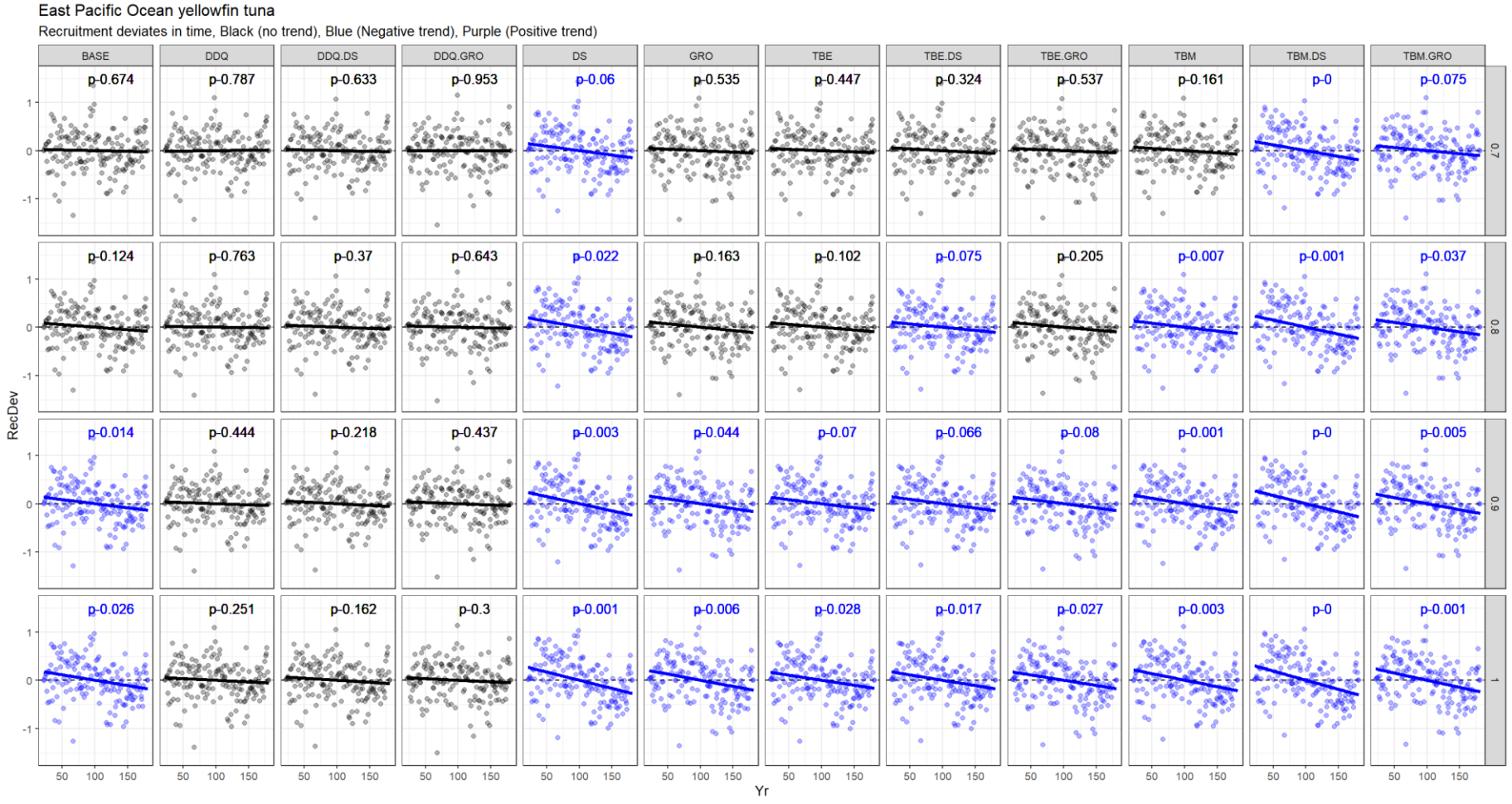
EPO Bigeye

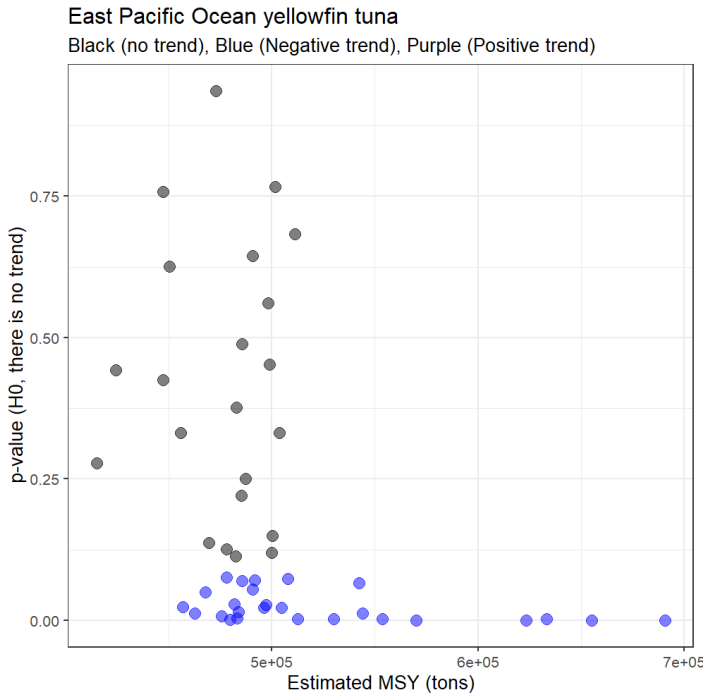




Results (Other tropical tunas' SA)

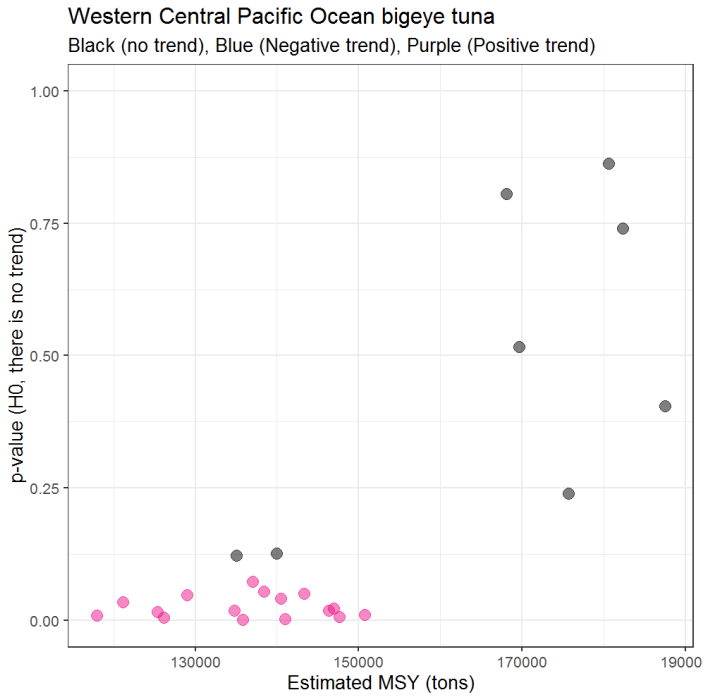
EPO Yellowfin





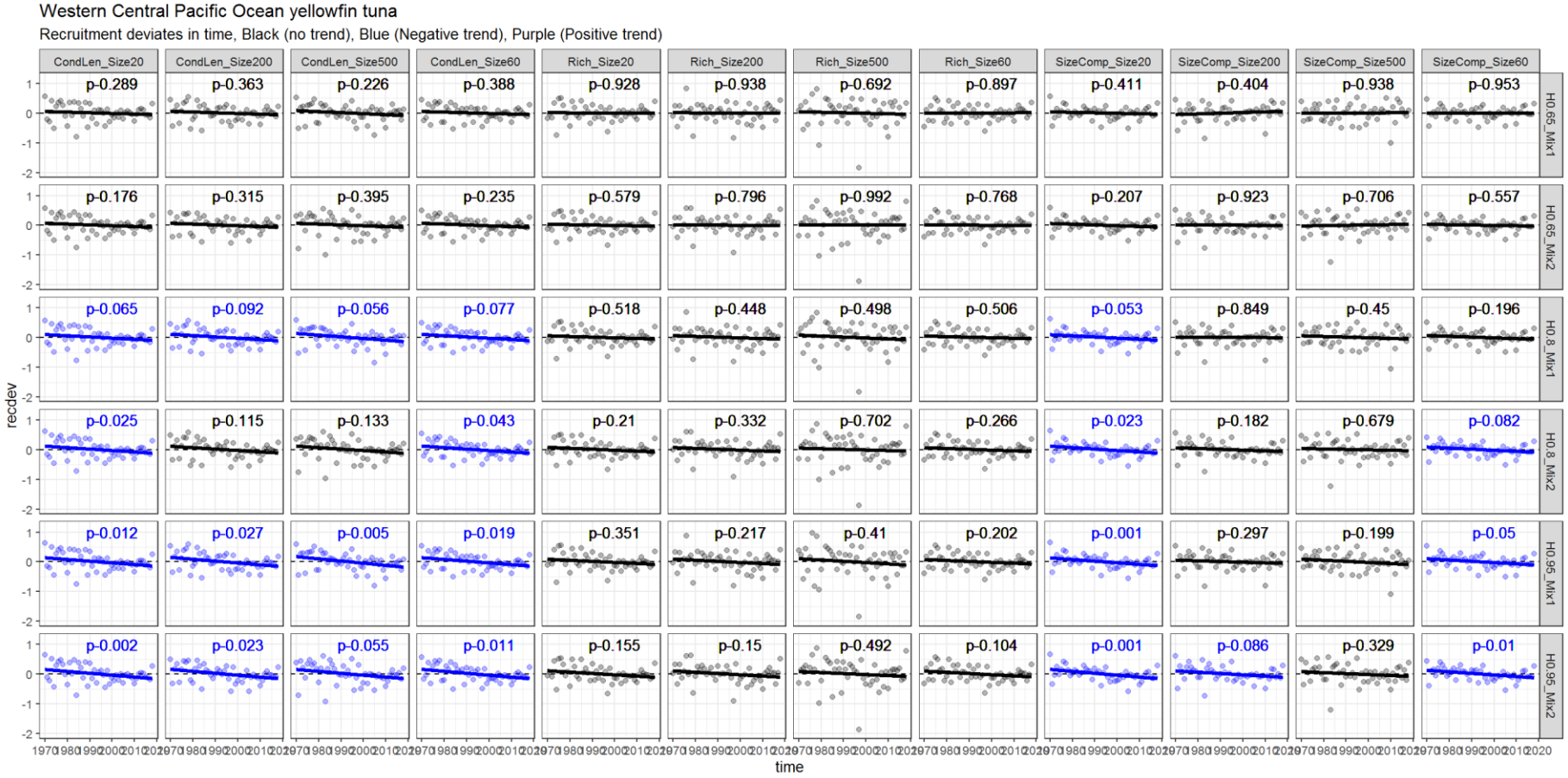
Results (Other tropical tunas' SA)

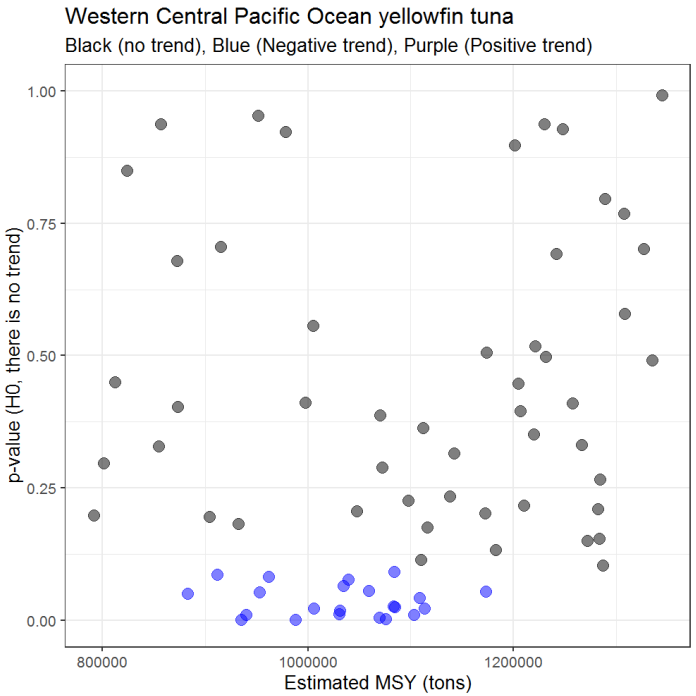
WCPO Bigeye



Results (Other tropical tunas' SA)

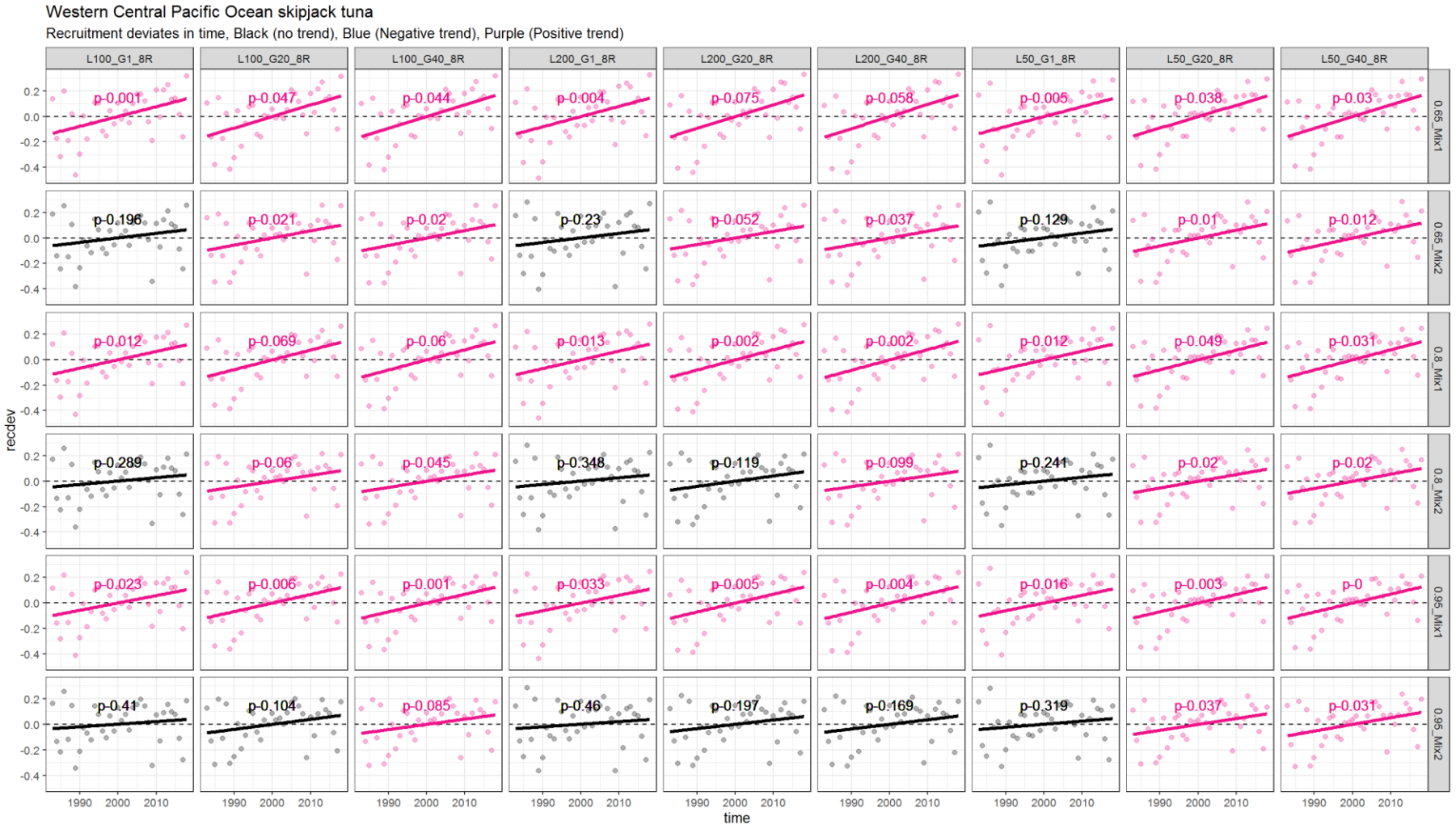
WCPO Yellowfin

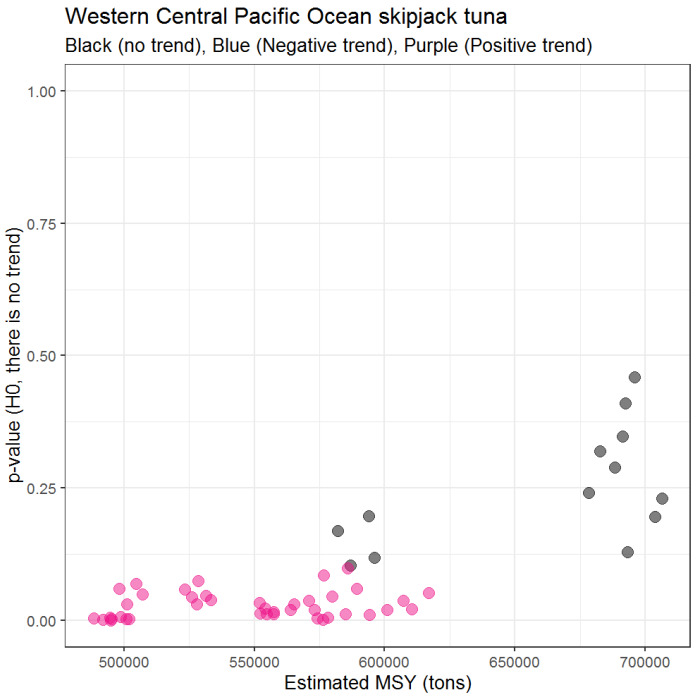




Results (Other tropical tunas' SA)

WCPO Skipjack





Discussion

- Assessments of tropical tunas contain trends in recruitment deviates.
- Trends associated with large/low values of estimated productivity and differences with assumptions run without rec devs.
- When recruitment deviates increase, these can compensate biomass in periods of large catch. When this happens, process error is not random (~variability) but part of response to fishing.
- Trends in process error can also be due to misspecification of parameters and data conflict.
- Projections for K2SM should include recent recruitment deviates (reduce uncertainty).
- If evidence of changes on underlying productivity (e.g. climate change), reference points updated in all models (or as factors) but in a large ensemble context...
- p-value of no-trend useful when using large ensembles of models (ICCAT/IOTC) together with other diags.
- Models with a low p-value for no-trend (threshold 0.1 arbitrary) should be analysed (re-configured) before selection for ensemble to develop management advice.
- For Joint Tuna RFMO, harmonize specifications of rec devs (phases, role, constrains...).

Thanks!

Discussion

- Assessments of tropical tunas contain trends in recruitment deviates.
- Trends associated with large/low values of estimated productivity and differences with assumptions run without rec devs.
- When recruitment deviates increase, these can compensate biomass in periods of large catch. When this happens, process error is not random (~variability) but part of response to fishing.
- Trends in process error can also be due to misspecification of parameters and data conflict.
- Projections for K2SM should include recent recruitment deviates (reduce uncertainty).
- If evidence of changes on underlying productivity (e.g. climate change), reference points updated in all models (or as factors) but in a large ensemble context...
- p-value of no-trend useful when using large ensembles of models (ICCAT/IOTC) together with other diags.
- Models with a low p-value for no-trend (threshold 0.1 arbitrary) should be analysed (re-configured) before selection for ensemble to develop management advice.
- For Joint Tuna RFMO, harmonize specifications of rec devs (phases, role, constrains...).