Stock assessment of *Coryphaena hippurus* in the South-East Pacific Ocean under environmental cycles

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METHODOLOGY - DATA

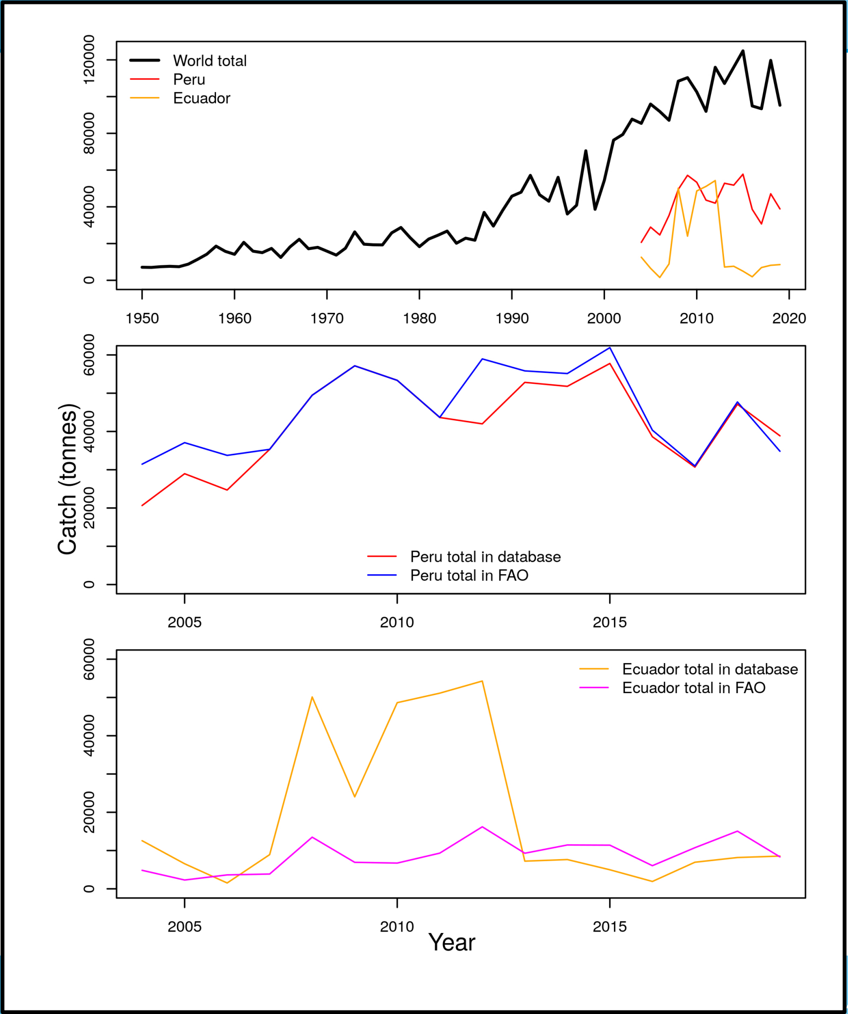
- IMARPE and IPIAP compiled a database of monthly total catch, total fishing effort, and mean length in the catch, from Jan. 2004 to Dec. 2019.

- The database has data from four fleets operating on the stock in the region:
  - Peruvian artisanal oceanic
  - Peruvian fiberglass coastal
  - Ecuadorian artisanal oceanic
  - Ecuadorian artisanal coastal

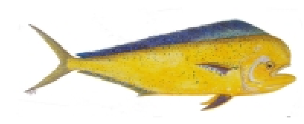
METHODOLOGY - DATA

- Fishing effort is measured as:
  - Peruvian artisanal: Nº of days of fishing
  - Peruvian fiberglass: Nº of fishing trips
  - Ecuadorian oceanic: Nº of fishing trips
  - Ecuadorian coastal: Nº of days of fishing

- Annual total catch reveals that this is the largest mahi fishery in the world and that Peruvian data for stock assessment is largely coincident with official statistics while Ecuadorian data differs from official statistics for the period of 2008 to 2012.



METHODOLOGY – STOCK ASSESSMENT WITH GENERALIZED DEPLETION MODEL



Stock Assessment of the dolphinfish (*Coryphaena hippurus*) in the South-East Pacific Ocean

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$$C_t = k_1 E_{1,t}^{\alpha_1} N_t^{\beta_1} + k_2 E_{2,t}^{\alpha_2} N_t^{\beta_2} + k_3 E_{3,t}^{\alpha_3} N_t^{\beta_3} + k_4 E_{4,t}^{\alpha_4} N_t^{\beta_4}$$

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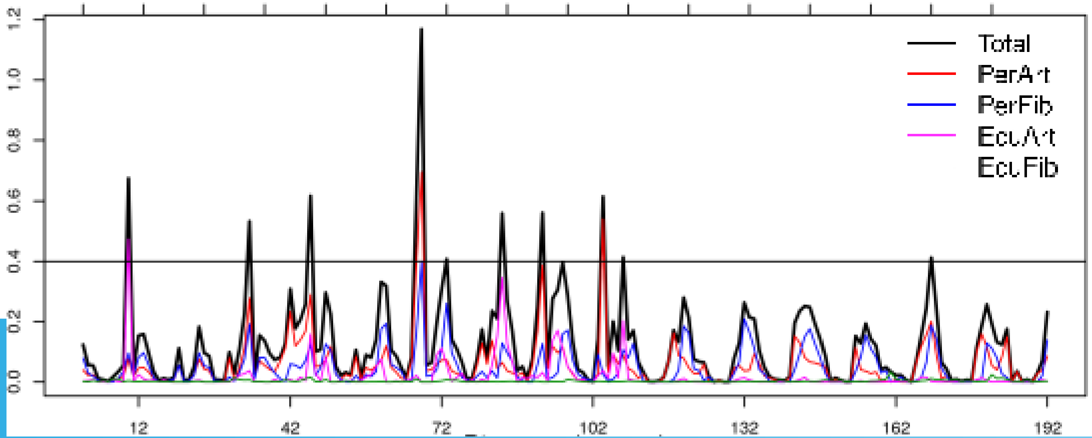
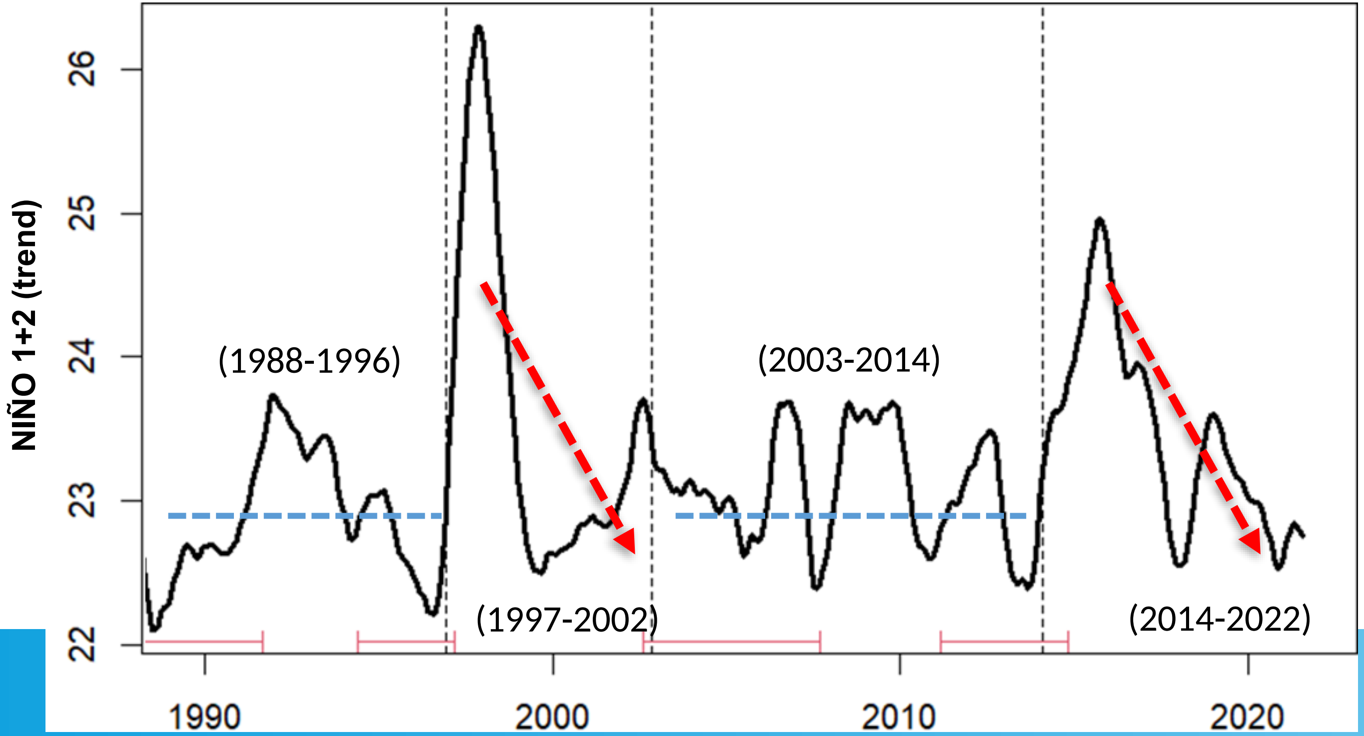
$$\begin{aligned}
C_t = {} & k_1 E_{1,t}^{\alpha_1} e^{M/2} \left(N_0 e^{-Mt} - e^{M/2} \left[\sum_{i=1}^{i=t-1} C_{1,i} e^{-M(t-i-1)} \right] + \sum_{j=1}^{j=16} I_{1,j} R_{1,j} e^{-M(t-\tau_{1,j})} \right)^{\beta_1} + \\
& k_2 E_{2,t}^{\alpha_2} e^{M/2} \left(N_0 e^{-Mt} - e^{M/2} \left[\sum_{i=1}^{i=t-1} C_{2,i} e^{-M(t-i-1)} \right] + \sum_{j=1}^{j=16} I_{2,j} R_{2,j} e^{-M(t-\tau_{2,j})} \right)^{\beta_2} + \\
& k_3 E_{3,t}^{\alpha_3} e^{M/2} \left(N_0 e^{-Mt} - e^{M/2} \left[\sum_{i=1}^{i=t-1} C_{3,i} e^{-M(t-i-1)} \right] + \sum_{j=1}^{j=16} I_{3,j} R_{3,j} e^{-M(t-\tau_{3,j})} \right)^{\beta_3} + \\
& k_4 E_{4,t}^{\alpha_4} e^{M/2} \left(N_0 e^{-Mt} - e^{M/2} \left[\sum_{i=1}^{i=t-1} C_{4,i} e^{-M(t-i-1)} \right] + \sum_{j=1}^{j=16} I_{4,j} R_{4,j} e^{-M(t-\tau_{4,j})} \right)^{\beta_4}
\end{aligned}$$

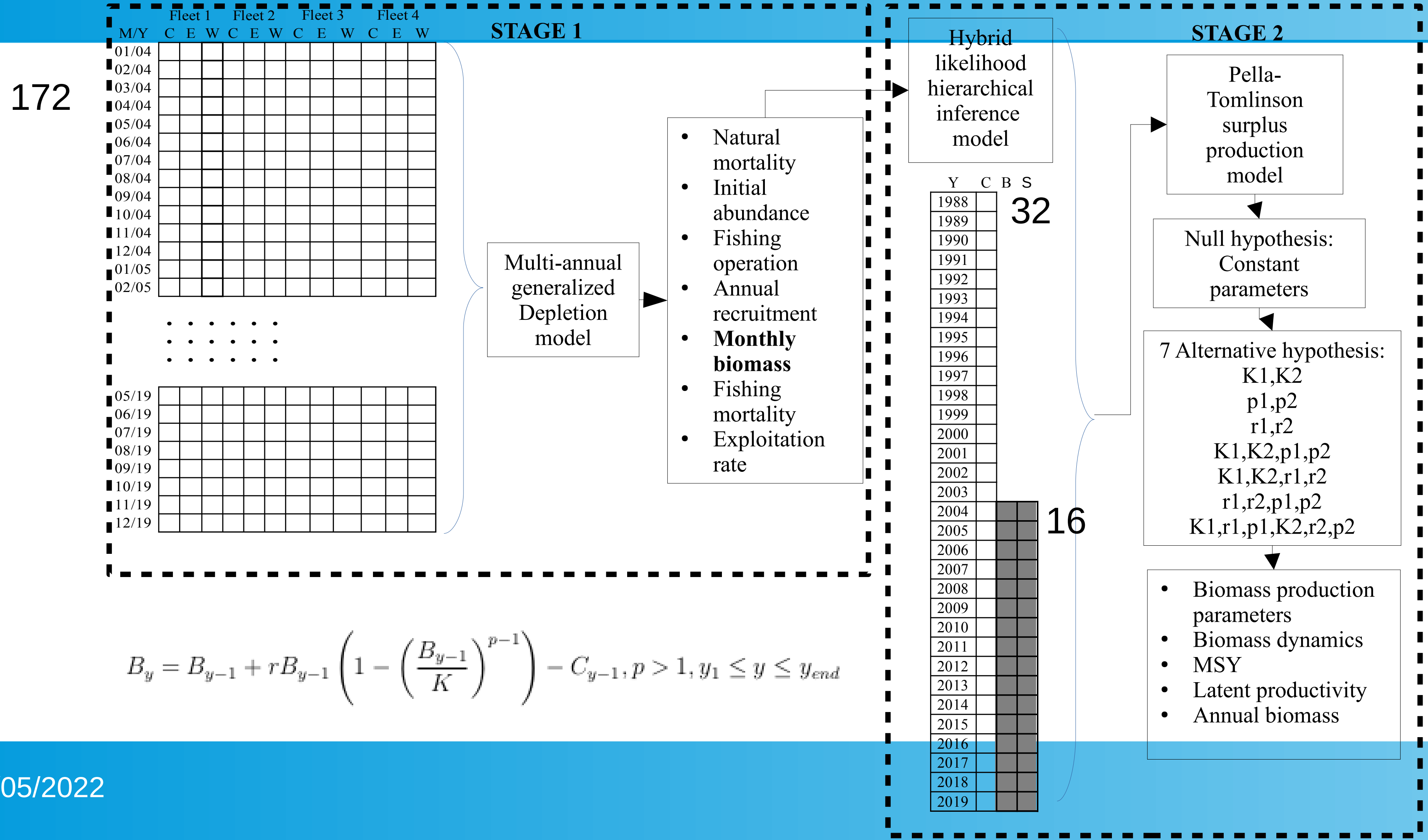


METHODOLOGY – POPULATION DYNAMICS AND ENVIRONMENTAL CYCLES

- Applying the breakpoint test on the NOAA monthly temperature index trend (NIÑO 1+2), 3 regimes shifts were identified: 1988-1996; 1997-2002; 2003-2013; 2014-2022.
- 1988-2022: dorado alternated between regimes of “cold” and “warm” oceanographic conditions.
- So we explore possible changes in productivity on account of that environmental cycle.



METHODOLOGY – CONCEPTUAL DIAGRAM



$$B_y = B_{y-1} + rB_{y-1}\left(1 - \left(\frac{B_{y-1}}{K}\right)^{p-1}\right) - C_{y-1}, p > 1, y_1 \leq y \leq y_{end}$$

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ICES CIEM International Council for the Exploration of the Sea / Conseil International pour l'Exploration de la Mer

A multiannual five-fleet generalized depletion model for the stock assessment of the Mediterranean dolphinfish (*Coryphaena hippurus*) fishery

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Several model variants are fitted using a customized version of R package CatDyn.

METHODOLOGY – STAGE 2 – PELLA-TOMLINSON SURPLUS PRODUCTION MODEL

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Hierarchical statistical framework to combine generalized depletion models and biomass dynamic models in the stock assessment of the Chilean sea urchin (*Loxechinus albus*) fishery

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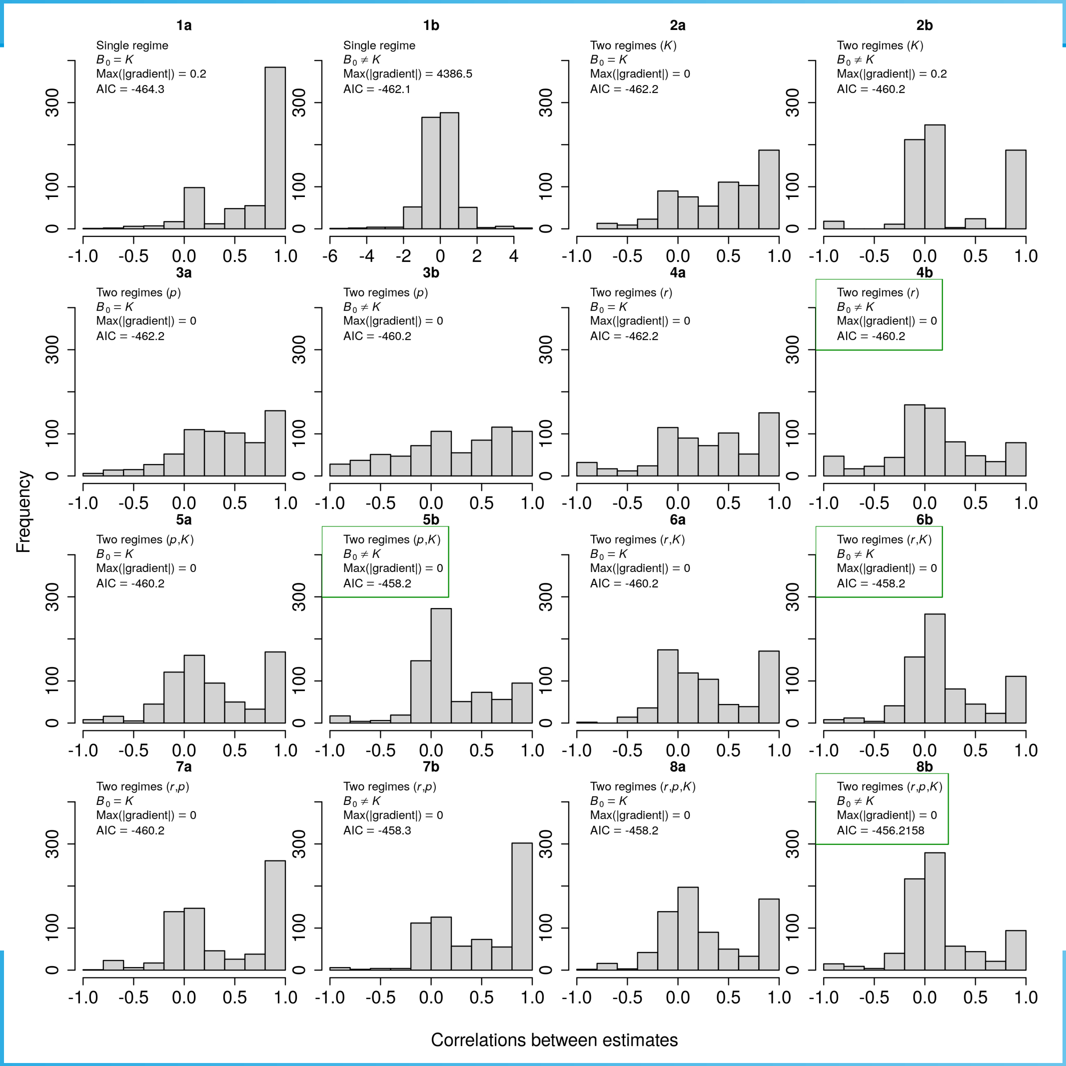
16 model variants were fitted using AD Model Builder.

RESULTS – SURPLUS PRODUCTION MODEL

Sixteen scenarios of regime change were fitted.

Only four combined good correlations, low gradients, and low AIC:

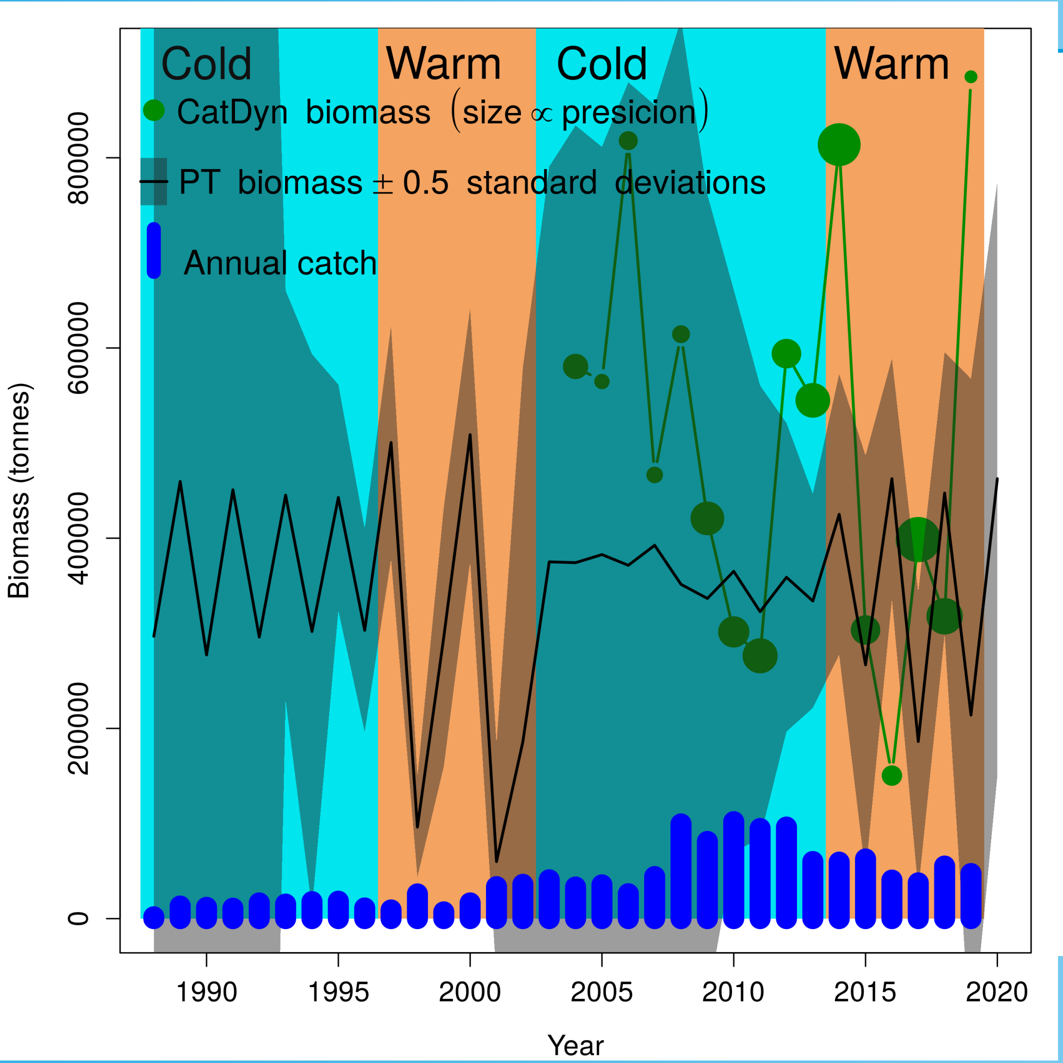
- **Change in *r*** only from cold, to warm, to cold, and back to warm regimes (**4b**).
- **Change in *p* and *K*** from cold, to warm, to cold, and back to warm regimes (**5b**).
- **Change in *r* and *K*** from cold, to warm, to cold, and back to warm regimes (**6b**).
- **Change in *r*, *p* and *K*** from cold, to warm, to cold, and back to warm regimes (**8b**).



RESULTS – SURPLUS PRODUCTION MODEL

The best AIC and standard errors of parameters was obtained from scenario **4b**, Change in *r* only from cold, to warm, to cold, and back to warm regimes

- During warm regimes the stock shows wider fluctuations in biomass and yet the biomass trajectory is estimated with much more statistical presicion.
- The annual catch has been well under the biomass for most of the time series, and particularly in recent years.
- The stock present intrinsic fluctuations that get amplified or diminished by environmental fluctuations.



RESULTS – SURPLUS PRODUCTION MODEL

Regime nature	Initial biomass	Parameter	MLE	SE	CV (%)
r1 → r2 → r1 – r2	B0!=K	B0 (tonnes)	296,880	94,576,000	31857
		K (tonnes)	393,970	176,420	45
		r1 (1/yr) (Cold)	2.452	3.1	130
		r2 (1/yr) (Warm)	3.254	4.5	139
		p	1.907	1.2	67
		MSY1 (tonnes) (Cold)	225,481	155,486	69
		B_MSY1 (tonnes) (Cold)	193,356	99,986	52
		MSY2 (tonnes) (Warm)	299,203	185,832	62
		B_MSY2 (tonnes) (Warm)	193,356	99,986	52
Cold → Warm → Cold → Warm		**ATLP1 (tonnes) (Cold)**	**91,386**		
		Mean catch (tonnes) (Cold)	**41,569**		
		ATLP2 (tonnes) (Warm)	**70,731**		
		Mean catch (tonnes) (Warm)	**35,969**		

Gracias!