Using an updated ecosystem model of the eastern tropical Pacific Ocean to explore potential impacts of increased fishing effort on floating objects

Shane Griffiths, Leanne Fuller, Juan Valero, Carolina Minte-Vera, Haikun Xu & Cleridy Lennert-Cody

12th Meeting of the Scientific Advisory Committee, 10-14 May 2021. Document: SAC-12-13

Ecological sustainability

- IATTC mandated to ensure ecologically sustainability of EPO tuna fisheries
  - Antigua Convention, IATTC Resolutions, and improved reporting (SAC-10-14, SAC-10 INF-B)
  - Development of the “EASI-Fish” ERA model for data-poor species (SAC-09-12, BYC-09-01)
- Single species assessments important

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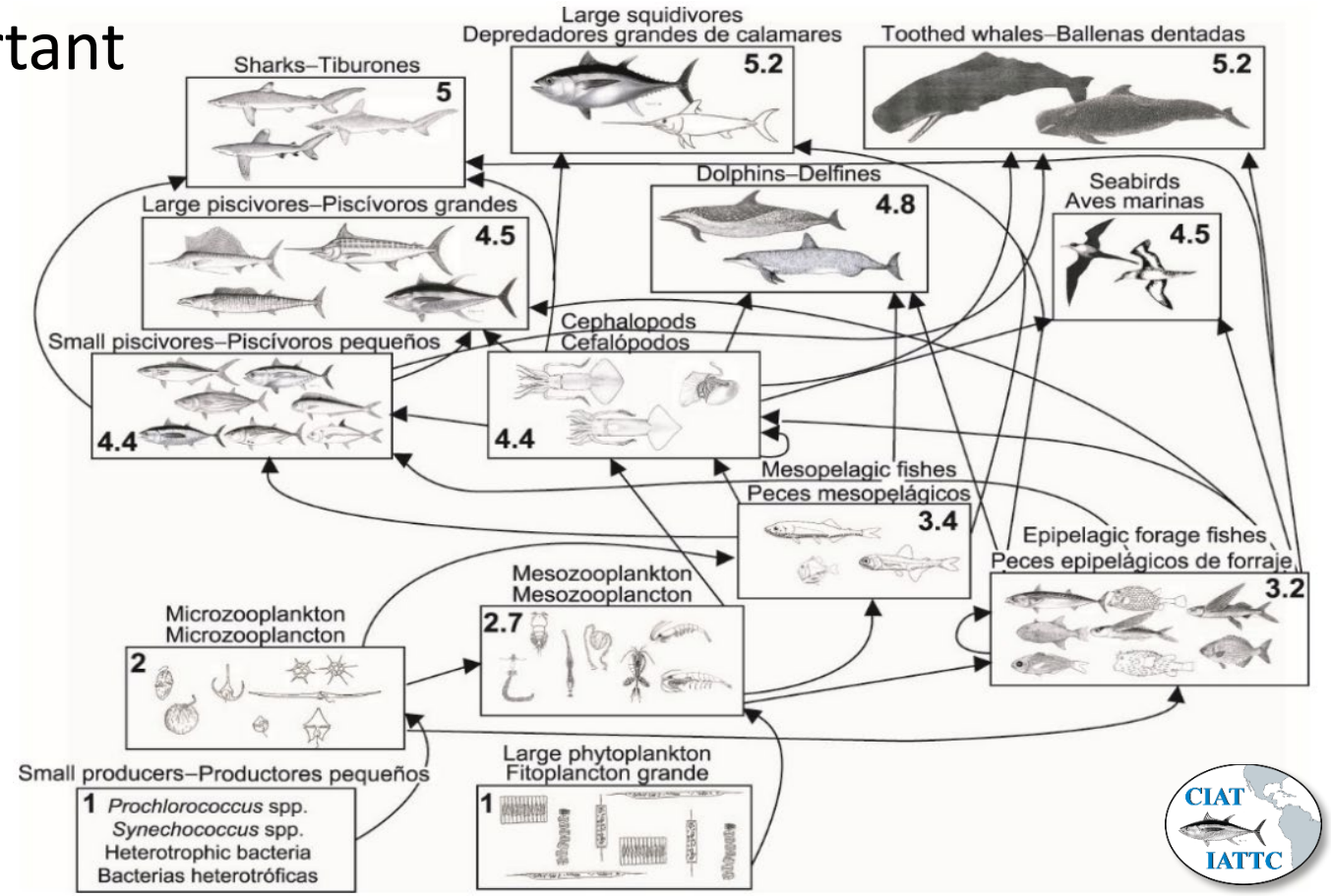
  - Development of the "EASI-Fish" ERA model for data-poor species (SAC-09-12, BYC-09-01)
- Single species assessments important
- But how does tuna fishing affect ecosystem dynamics?
- Diet analysis in 1990s and 2000s
- ETP ecosystem model ("ETP7")



ETP7 ecosystem model

- ETP7 used early software (v5.1) from 2003 and not used for reporting
- EwE (v6.6) improved with many ecological indicators
- In 2017, staff updated the ETP7 model with new data 1970-2014
- Since 2017, staff update ETP7 annually with catch and effort data and report on indicators in "*Ecosystem Considerations*" report (SAC-12-12)
- 2021 update (ETP-21) was required to:
  - Improve model structure to link ontogenetic stages (*e.g.,* small and large YFT)
  - Update biological parameters with new information since 2003
  - Rebalance the model after including revised longline catch estimates (SAC-12-12)
  - Calibrate the model to new time series data available for target and bycatch species

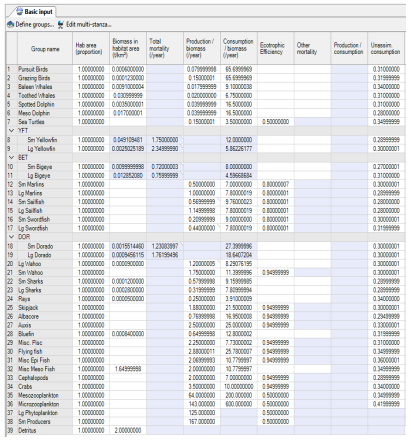
ETP7 ecosystem model

- Why not develop a new EPO model?

ETP7 ecosystem model

- Why not develop a new EPO model? A very long process

Parameterization
(Ecopath)



Basic input

Define groups... Edit multi-stanza...

	Group name	Hab area (proportion)	Biomass in habitat area (t/km²)	Total mortality (/year)	Production / biomass (/year)	Consumption / biomass (/year)	Ecotrophic Efficiency	Other mortality	Production / consumption	Unassim consumption
1	Pursuit Birds	1.00000000	0.00060000000		0.07999998	65.6999969				0.31000000
2	Grazing Birds	1.00000000	0.00012500000		0.15000001	65.6999969				0.31999999
3	Baleen Whales	1.00000000	0.00010000034		0.01799999	9.10000038				0.34000000
4	Toothed Whales	1.00000000	0.03099999		0.02000000	6.79000000				0.31000000
5	Spotted Dolphin	1.00000000	0.00350000001		0.03999999	16.5000000				0.31000000
6	Mexo Dolphin	1.00000000	0.01700000001		0.03999999	16.5000000				0.28000000
7	Sea Turtles	1.00000000			0.15000001	3.50000000	0.50000000			0.34999999
	YFT									
9	Sm Yellowfin	1.00000000	0.049129481	1.75000000		12.0000000				0.28999999
9	Lg Yellowfin	1.00000000	0.002525189	2.34999990		5.86226177				0.30000001
	BET									
10	Sm Bigeye	1.00000000	0.009999998	0.72000003		8.00000000				0.27000001
11	Lg Bigeye	1.00000000	0.012852080	0.75999999		4.59668684				0.31000000
12	Sm Marlins	1.00000000			0.50000000	7.00000000	0.80000007			0.30000001
13	Lg Marlins	1.00000000			1.00000000	7.80000019	0.80000001			0.28999999
14	Sm Sailfish	1.00000000			0.56999999	9.78000023	0.80000001			0.28000000
15	Lg Sailfish	1.00000000			1.14999998	7.80000019	0.80000001			0.28000000
16	Sm Swordfish	1.00000000			0.23999999	9.00000000	0.80000001			0.30000001
17	Lg Swordfish	1.00000000			0.44000000	7.80000019	0.80000001			0.31999999
	DOR									
18	Sm Dorado	1.00000000	0.001951446O	1.23083997		27.3999996				0.30000001
19	Lg Dorado	1.00000000	0.000946115	1.76199496		10.6407204				0.30000001
20	Lg Wahoo	1.00000000	0.00009000000		1.20000005	8.29679195				0.30000001
21	Sm Wahoo	1.00000000			1.75000000	11.3999996	0.94999999			0.30000001
22	Sm Sharks	1.00000000	0.00012500000		0.57999998	9.15999985				0.28999999
23	Lg Sharks	1.00000000	0.00023000000		0.31999999	7.80999994				0.28999999
24	Rays	1.00000000	0.00009500000		0.25000000	3.91000009				0.34000000
25	Skipjack	1.00000000			1.80000000	21.1000000	0.94999999			0.33000001
26	Albacore	1.00000000			0.76999998	16.9500008	0.94999999			0.29499999
27	Auxis	1.00000000			2.52000000	25.0000000	0.94999999			0.33000001
28	Bluefin	1.00000000	0.00094000000		0.64999998	12.8000002				0.31999999
29	Misc. Pisc	1.00000000			2.25000000	7.73000002	0.94999999			0.31000000
30	Flying fish	1.00000000			2.88000011	25.7800007	0.94999999			0.34999999
31	Misc Epi Fish	1.00000000			2.26999993	10.7799997	0.94999999			0.36000001
32	Misc Meso Fish	1.00000000	1.64999998		2.00000000	10.7799997				0.34999999
33	Cephalopods	1.00000000			2.00000000	7.00000000	0.94999999			0.28999999
34	Crabs	1.00000000			3.50000000	10.0000000	0.94999999			0.34000000
35	Mesozooplankton	1.00000000			64.0000000	200.000000	0.50000000			0.34999999
36	Microzooplankton	1.00000000			143.000000	600.000000	0.50000000			0.41999999
37	Lg Phytoplankton	1.00000000			125.000000		0.50000000			
38	Sm Producers	1.00000000			167.000000		0.50000000			
39	Detritus	1.00000000	2.00000000							

ETP7 ecosystem model

- Why not develop a new EPO model? A very long process

Parameterization
(Ecopath)

Balancing
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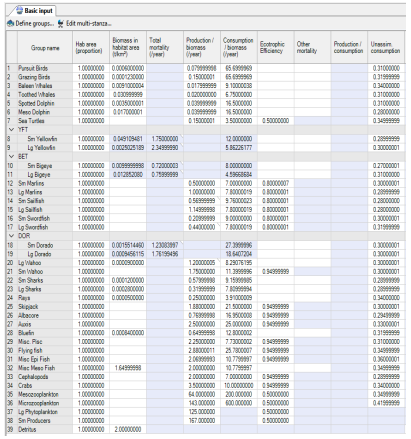

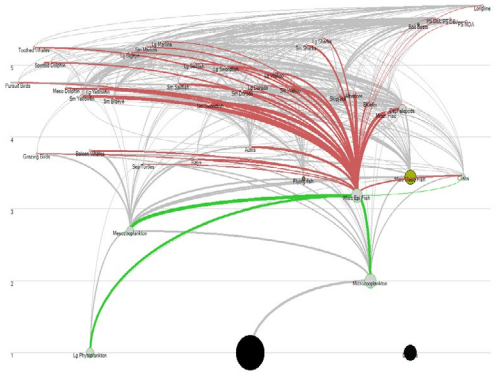

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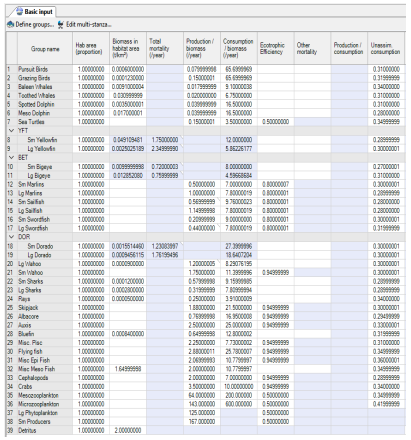
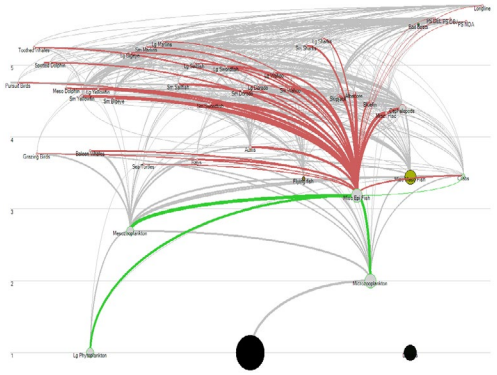
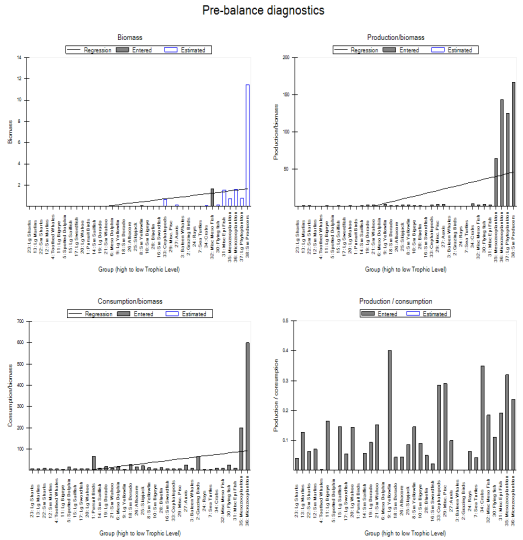
Parameterization (Ecopath) → **Balancing** (Ecopath) → **Diagnostics** (Ecopath)







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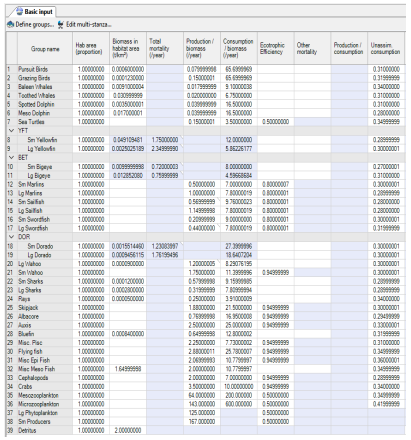

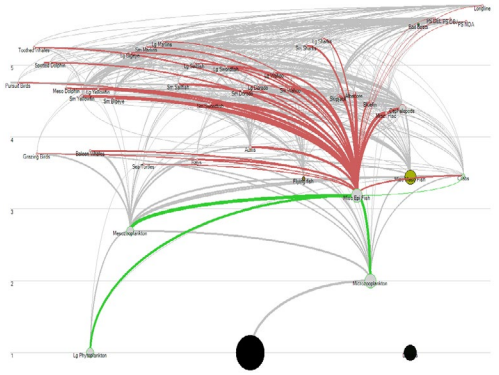

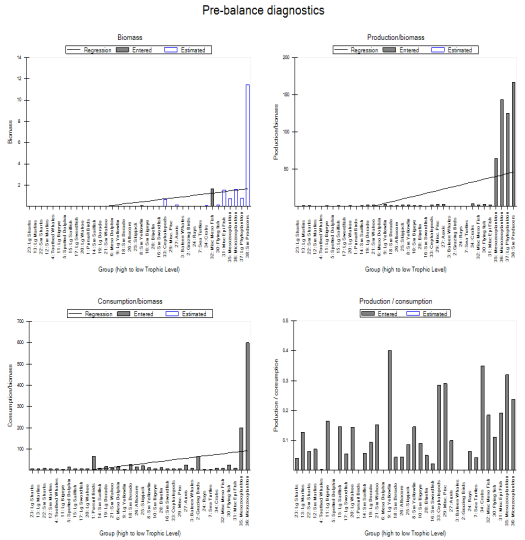

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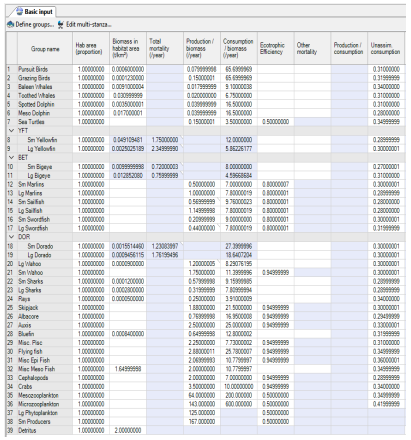

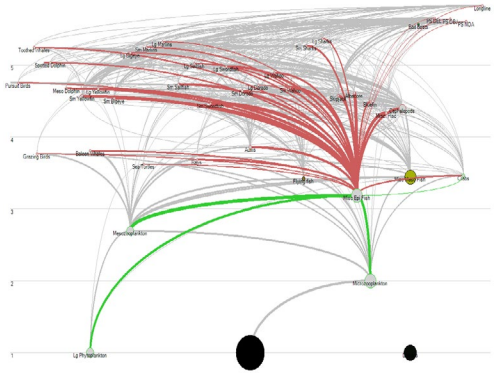

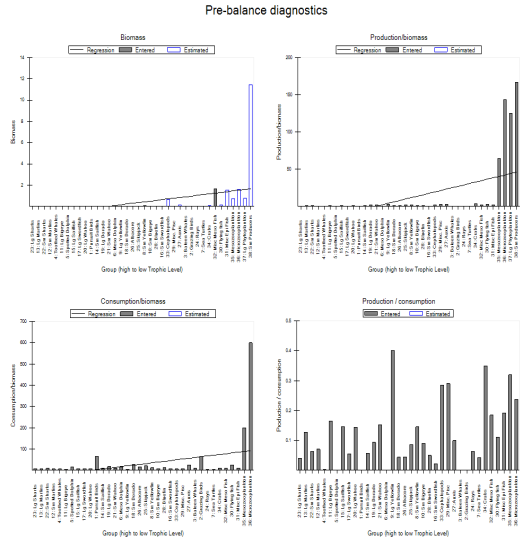

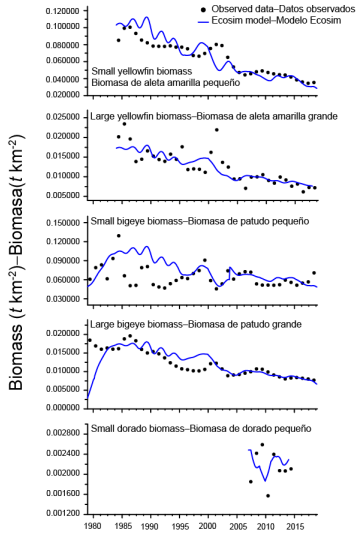

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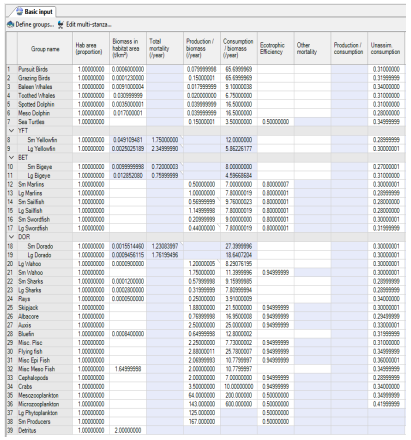

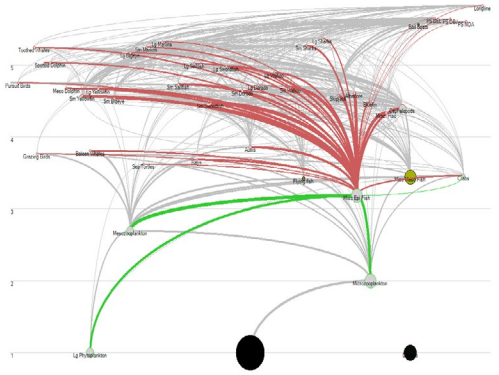

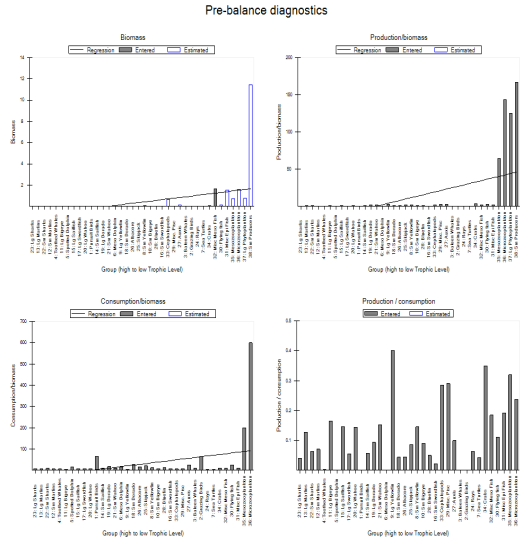

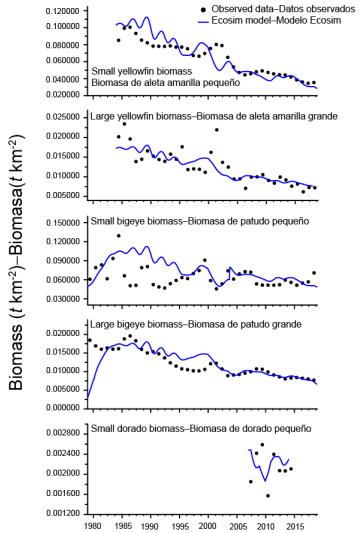

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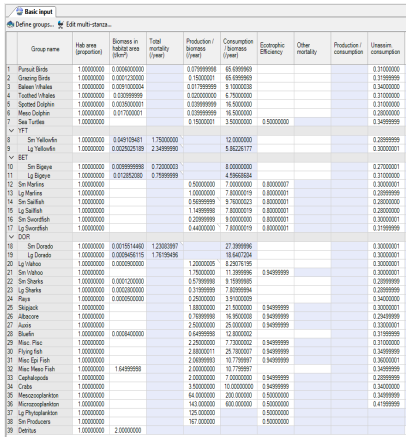

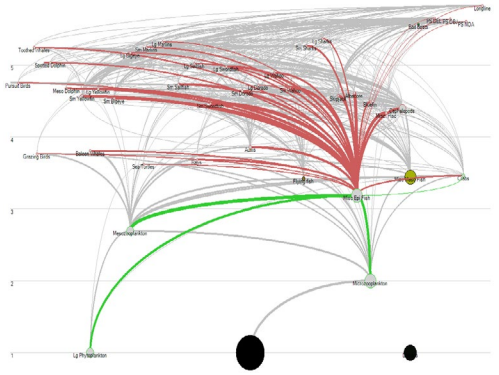

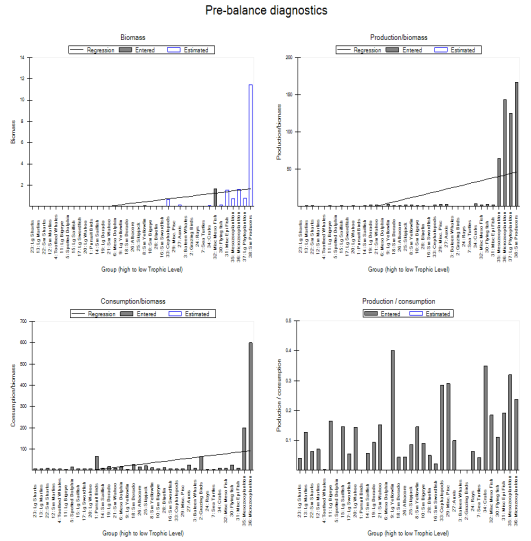

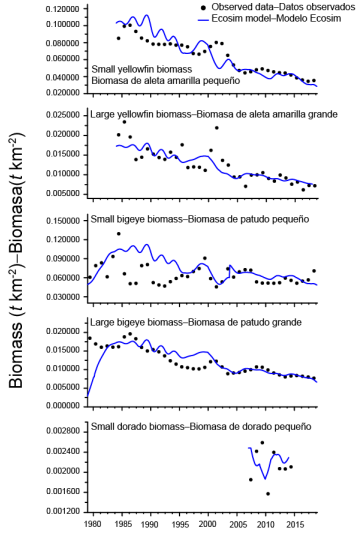

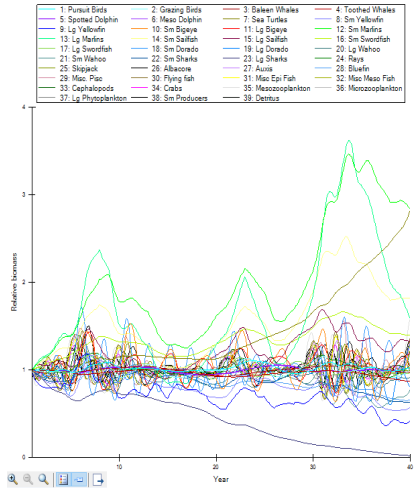

Revising ETP7 model structure

ETP7

	Group name
1	Pursuit Birds
2	Grazing Birds
3	Baleen Whales
4	Toothed Whales
5	Spotted Dolphin
6	Meso Dolphin
7	Sea Turtles
8	Sm Yellowfin
9	Lg Yellowfin
10	Sm Bigeye
11	Lg Bigeye
12	Sm Marlins
13	Lg Marlins
14	Sm Sailfish
15	Lg Sailfish
16	Sm Swordfish
17	Lg Swordfish
18	Sm Dorado
19	Lg Dorado
20	Sm Wahoo
21	Lg Wahoo
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  - But stages not linked - act as independent biomass pools

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ETP-21

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1	Pursuit Birds
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6	Meso Dolphin
7	Sea Turtles
	YELLOWFIN TUNA
8	Sm Yellowfin
9	Lg Yellowfin
	BIGEYE TUNA
10	Sm Bigeye
11	Lg Bigeye
12	Sm Marlins
13	Lg Marlins
	SAILFISH
14	Sm Sailfish
15	Lg Sailfish
	SWORDFISH
16	Sm Swordfish
17	Lg Swordfish
	DORADO
18	Sm Dorado
19	Lg Dorado
	WAHOO
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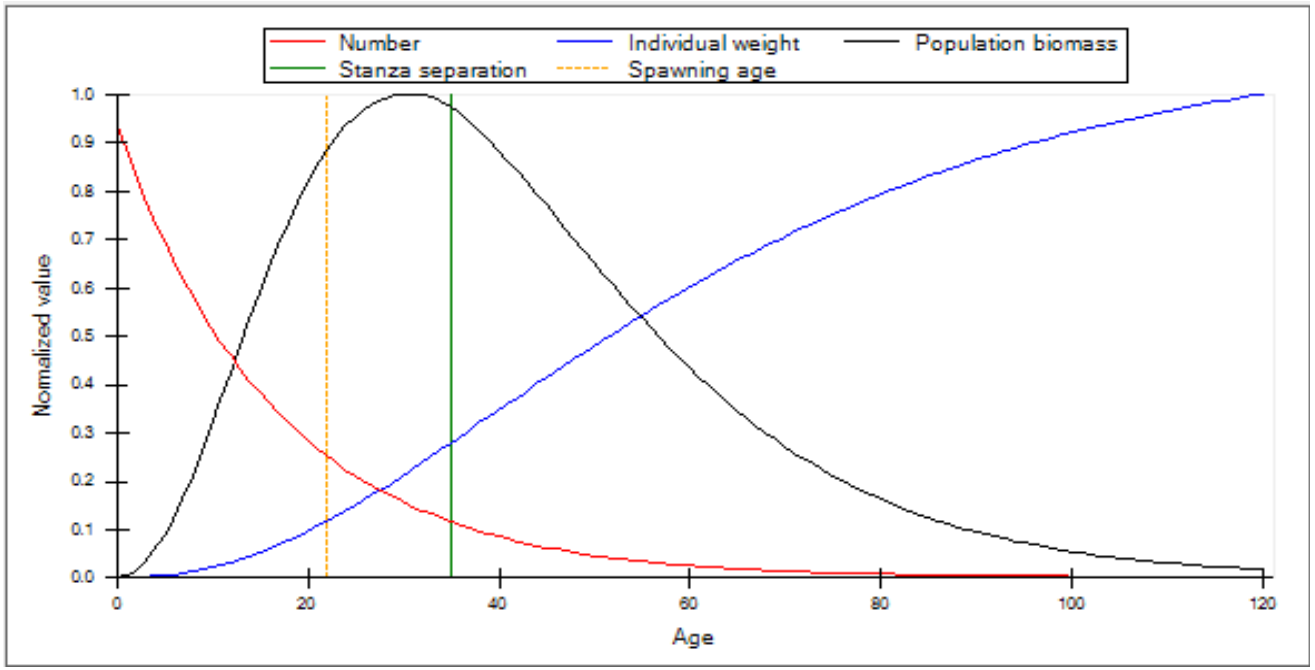
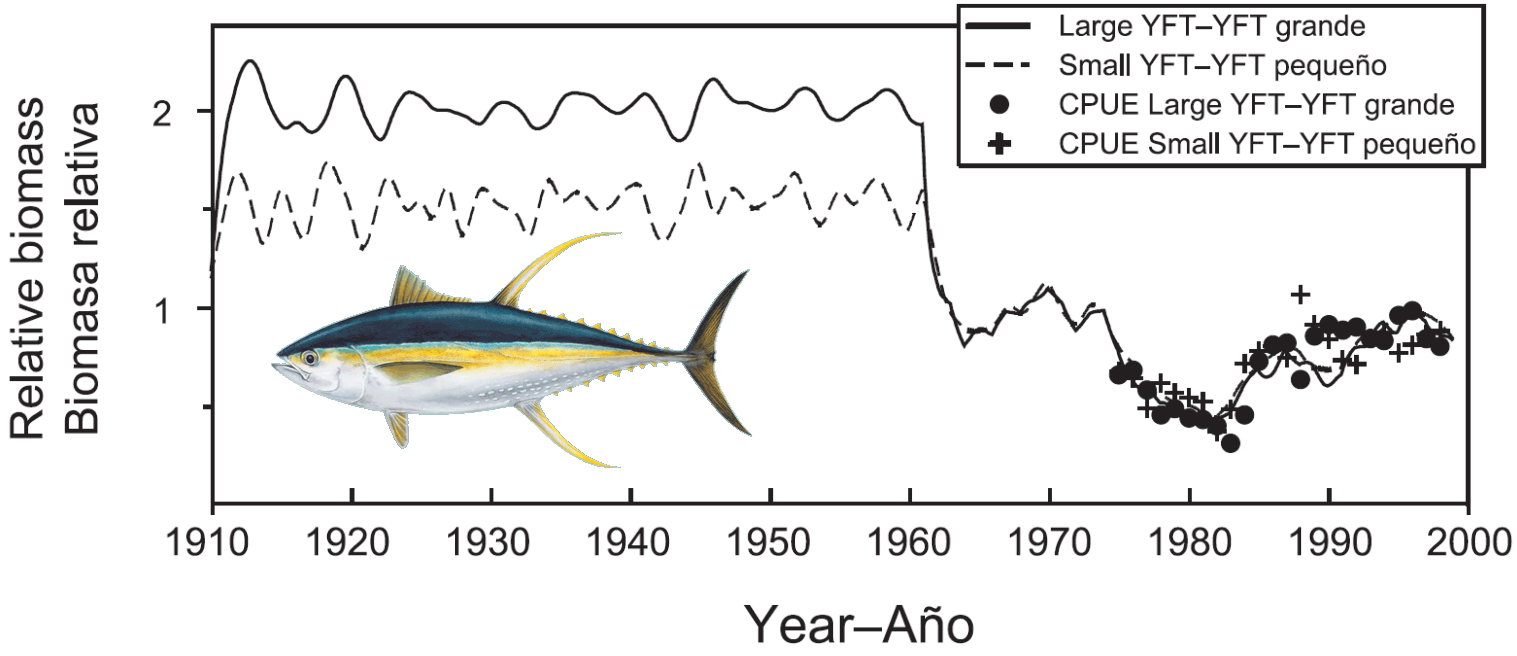


Results

Model Calibration to Time Series Data

Model Calibration

- ETP7 calibrated using time series 1975-1999 from stock assessments
  - Relative biomass
  - Total mortality (*Z*)
- Small & Large YFT
  - Excellent fit to CPUE data



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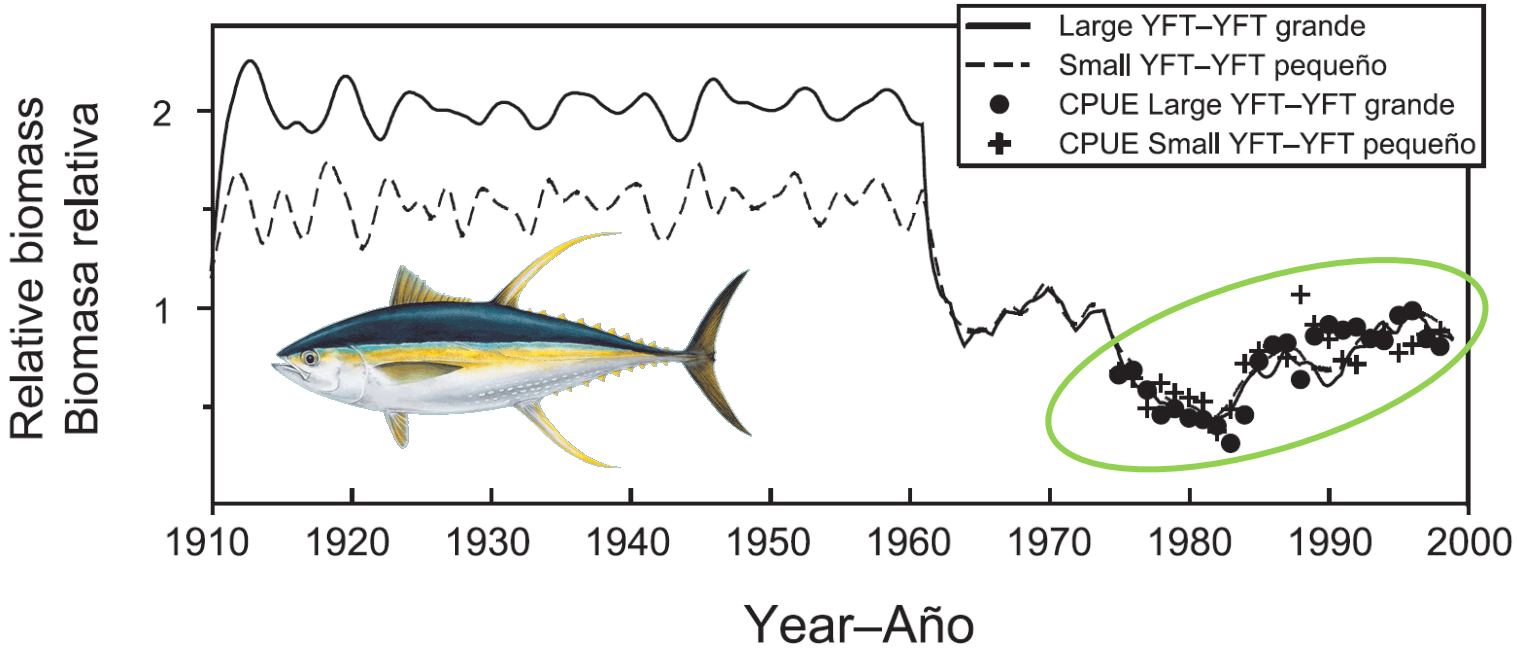

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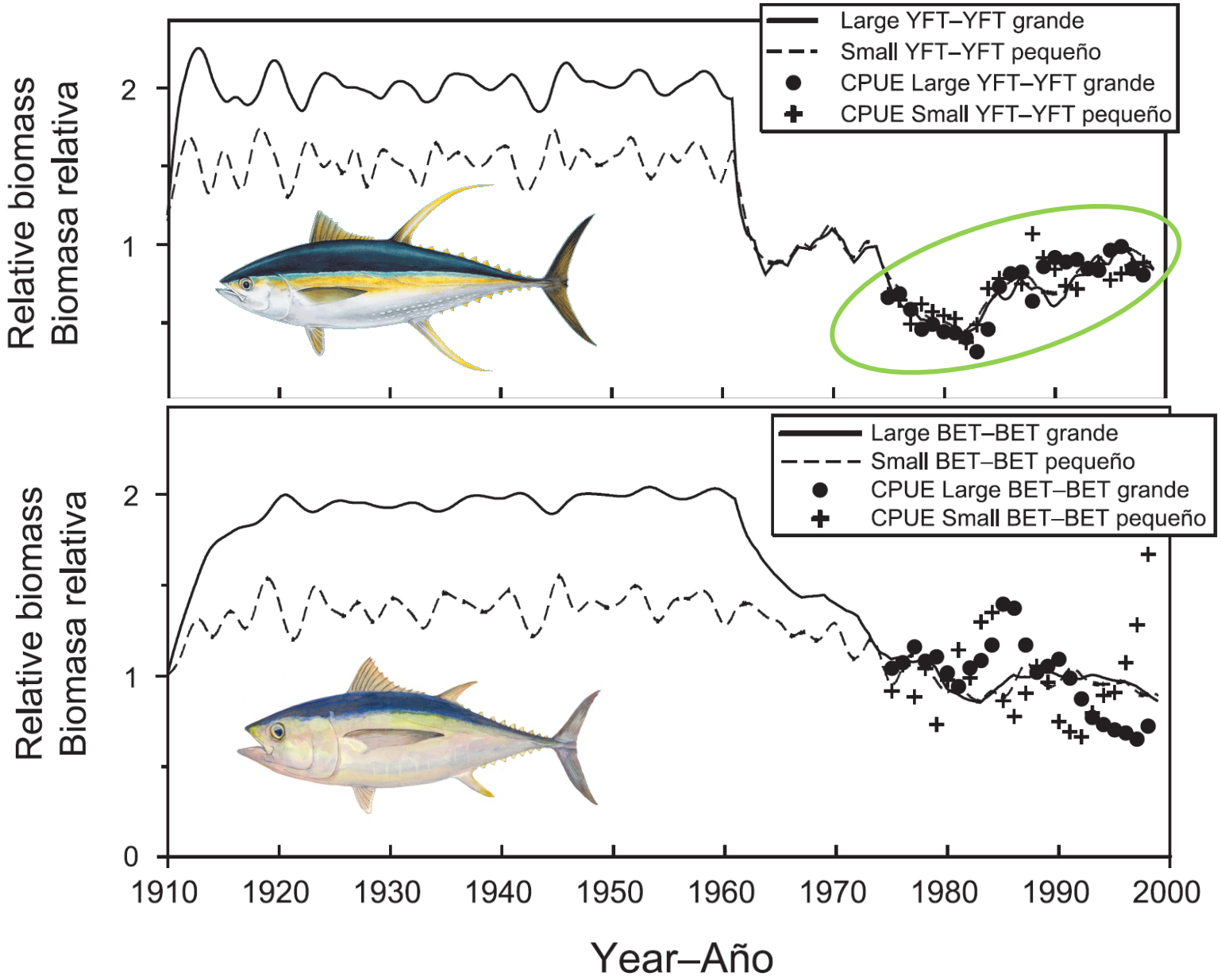
  - Small & large stanzas not linked?



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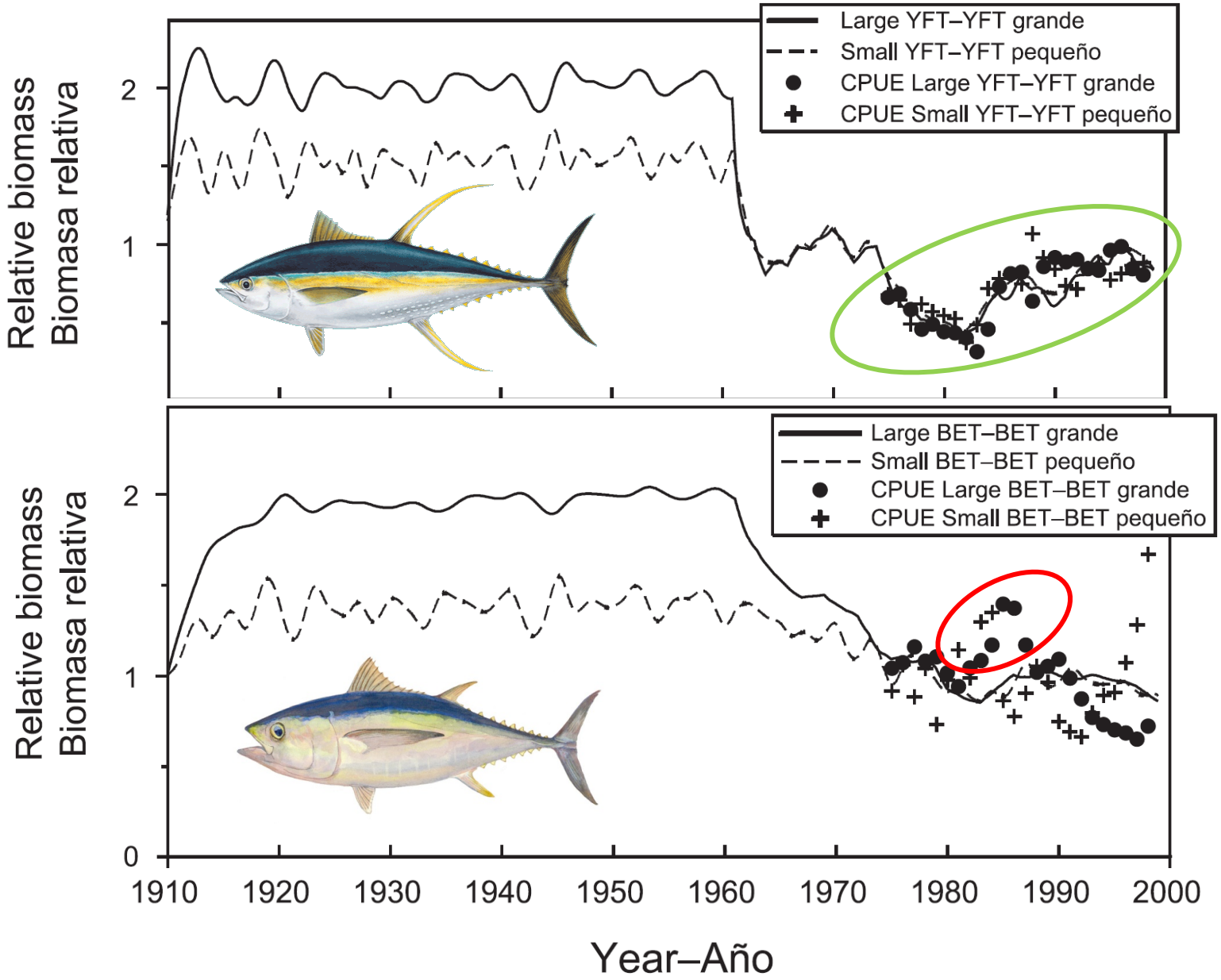

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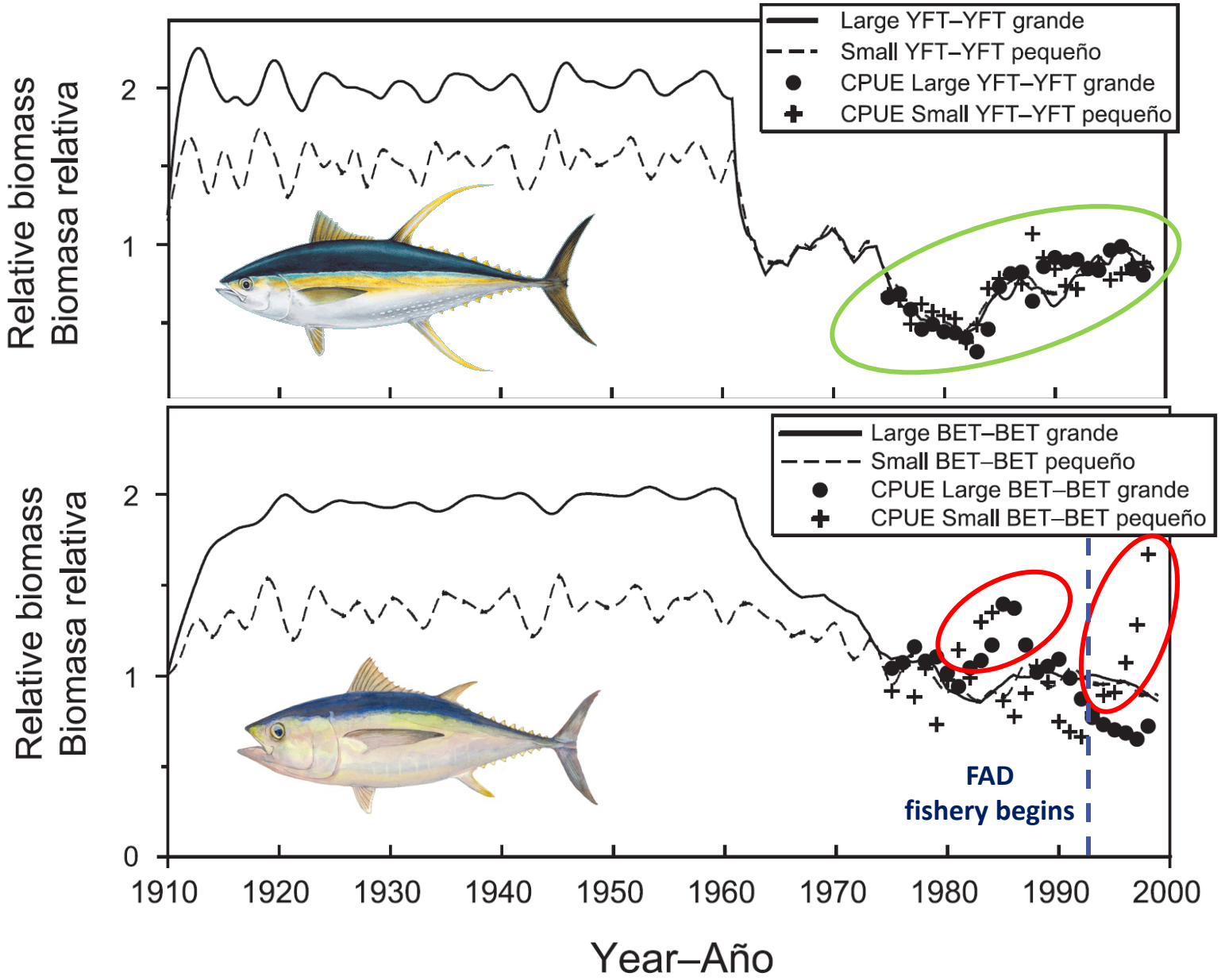
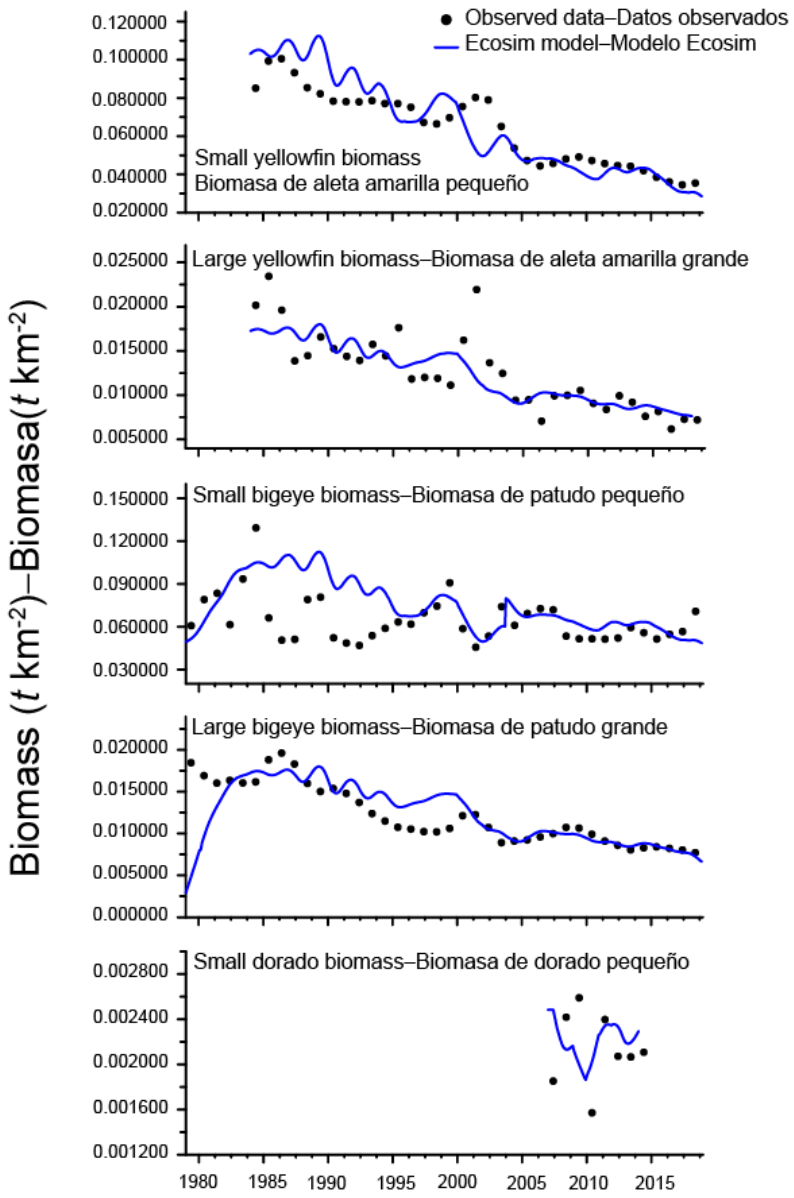
  - Nominal OBJ CPUE ≠ abundance?
- Poor predictive ability



Model Calibration

- Time series
  - Relative biomass
  - Fishing mortality (*F*)
  - Catch (retained + discarded)
- 25 functional groups
  - Small & large size classes
- Biomass and catch
  - Assessed species



Model Calibration

- Time series
  - Relative biomass
  - Fishing mortality (*F*)
  - Catch (retained + discarded)
- 25 functional groups
  - Small & large size classes
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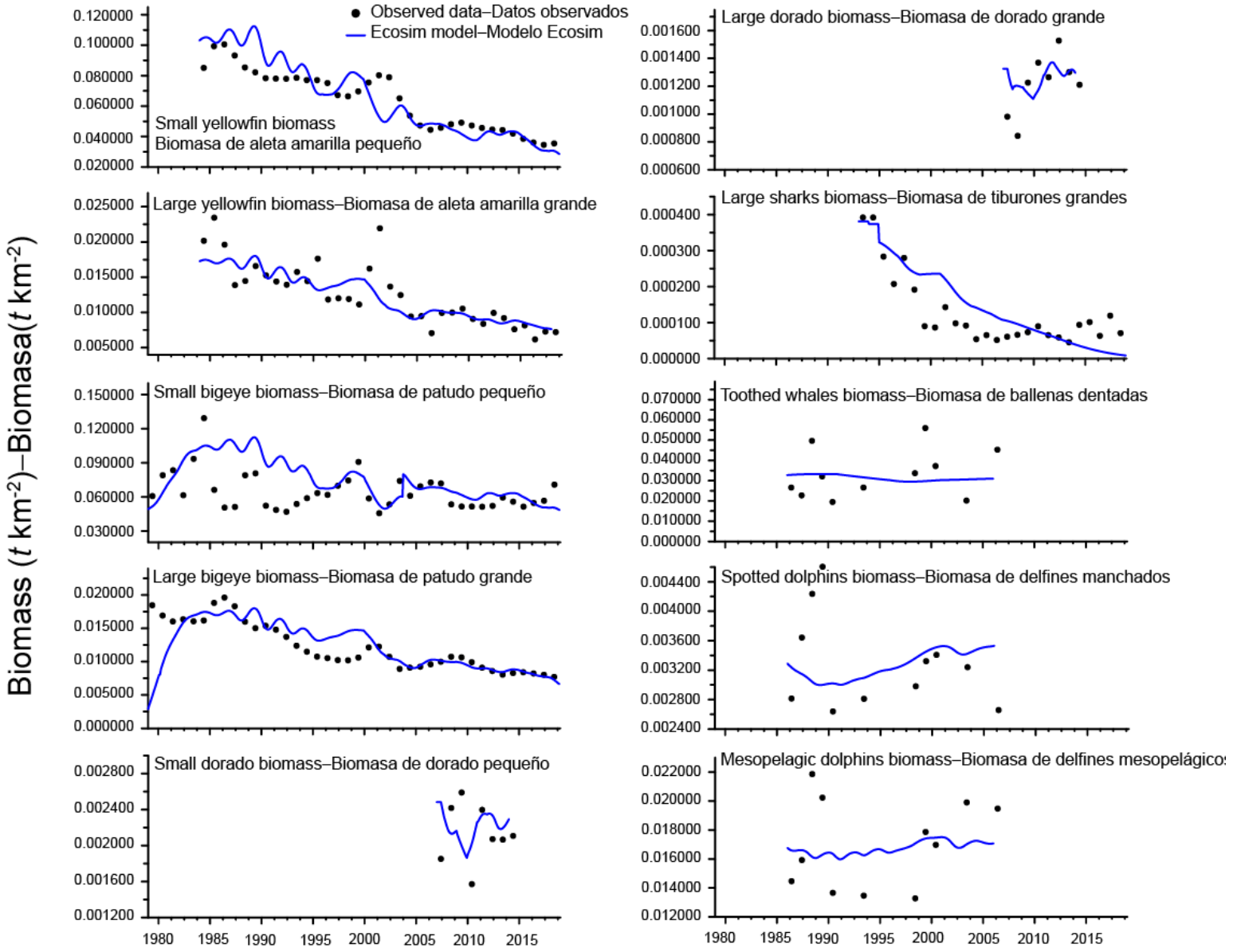

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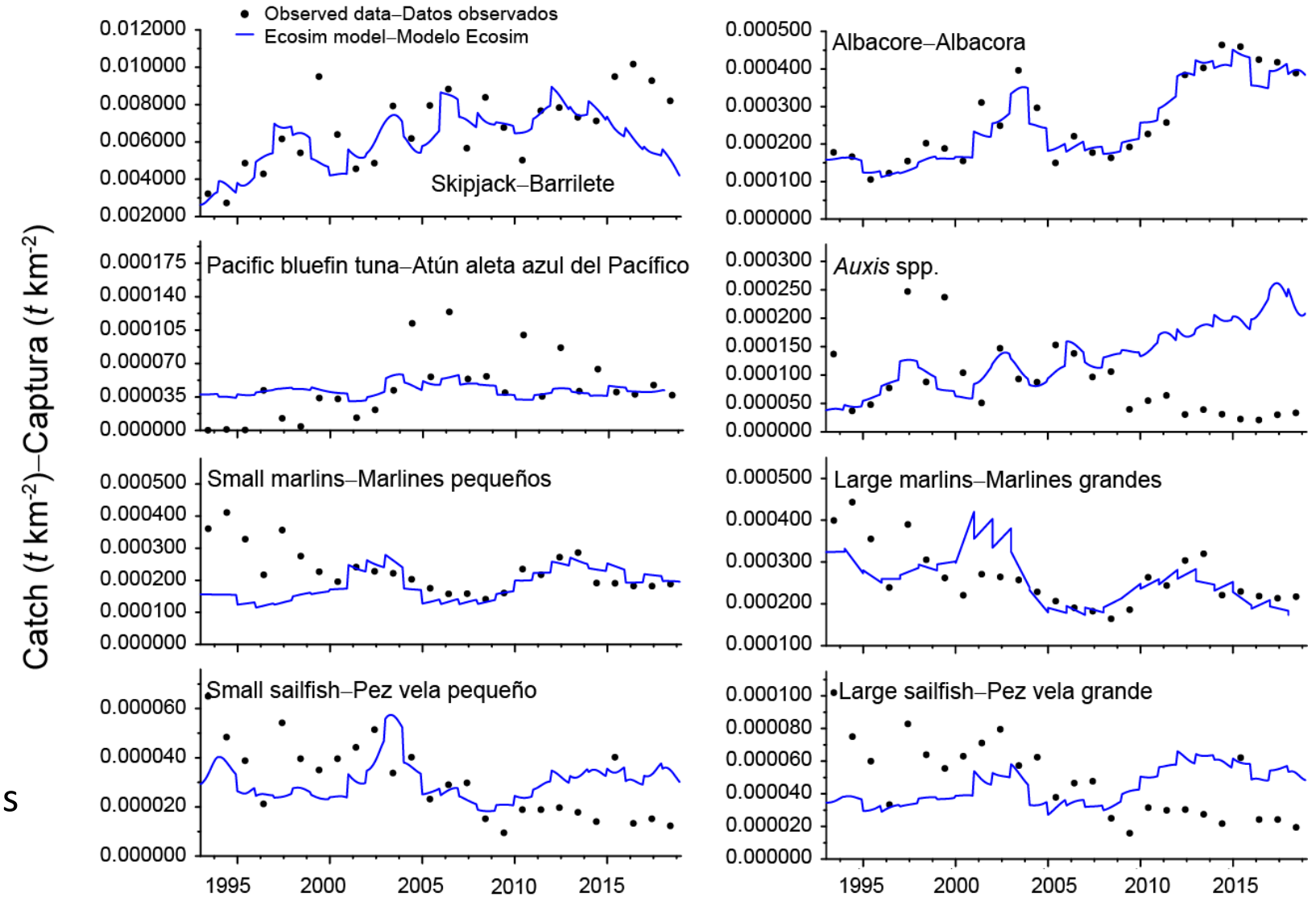

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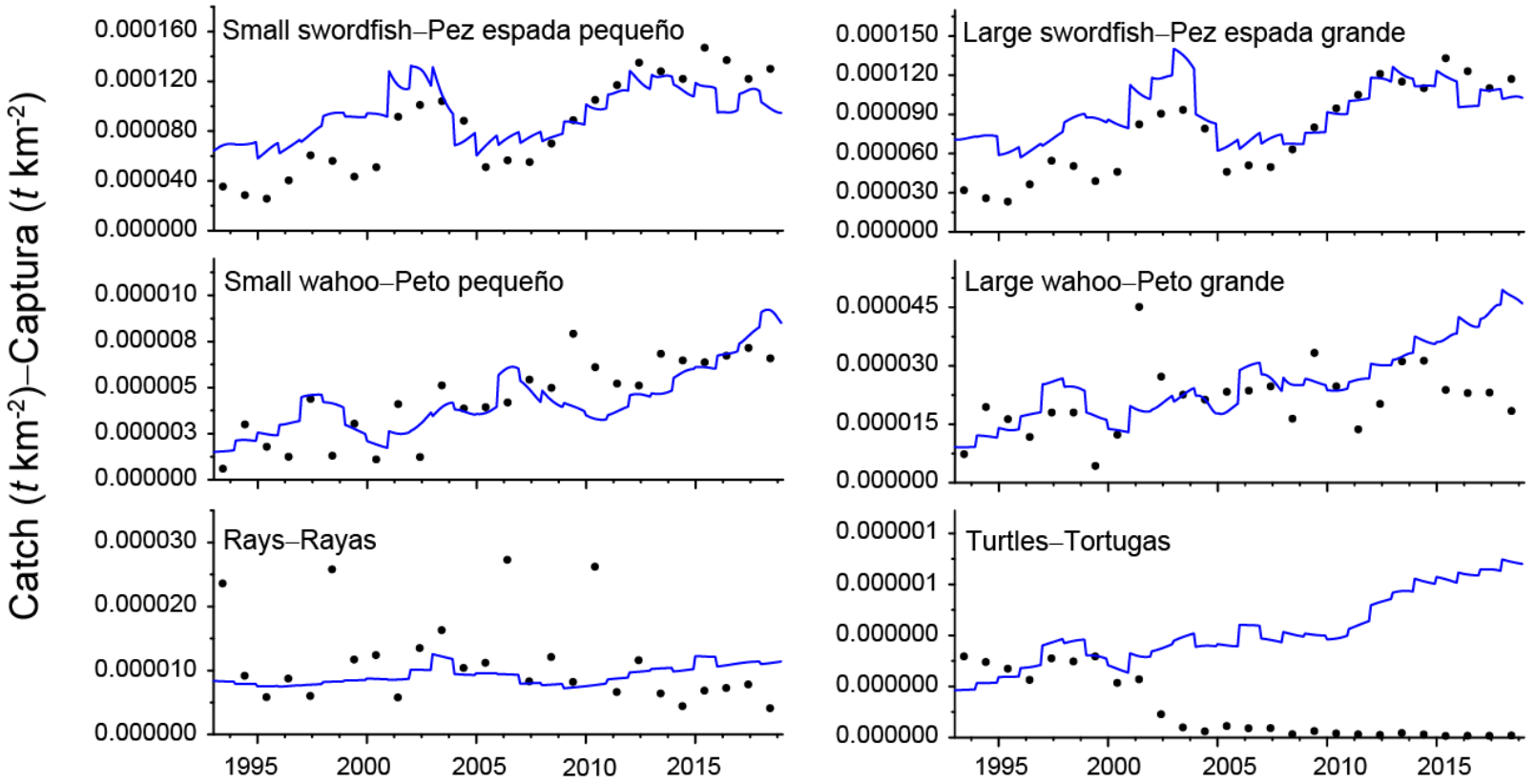
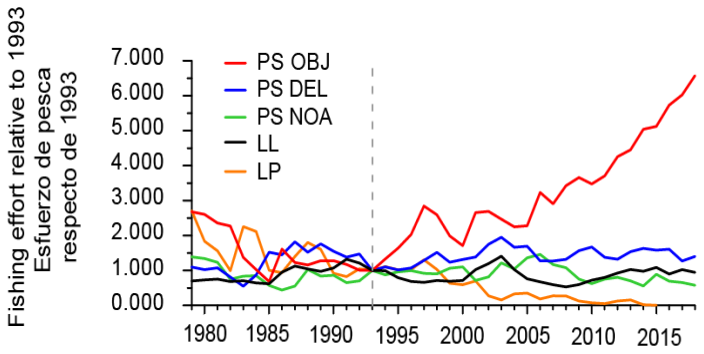


Results

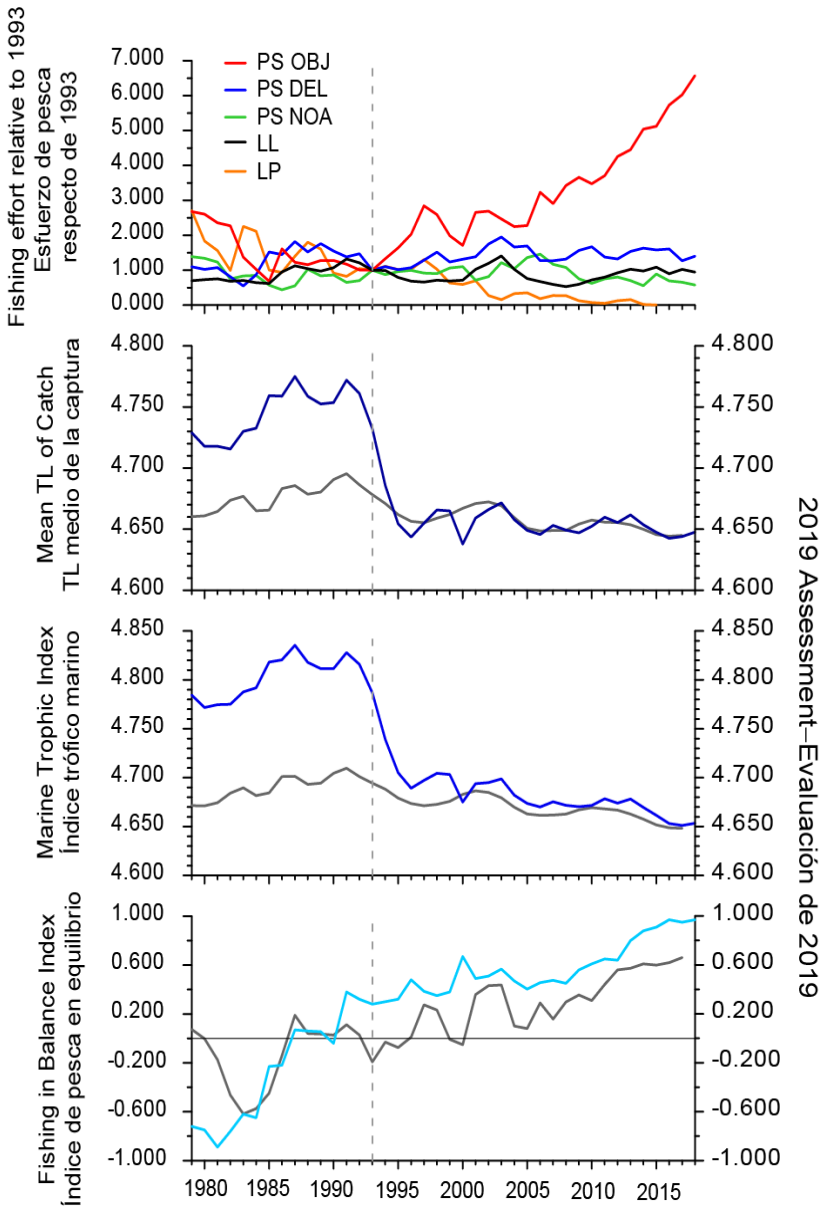
Historical changes in the structure of the ETP ecosystem for the period 1979-2018

Fishing-based indicators



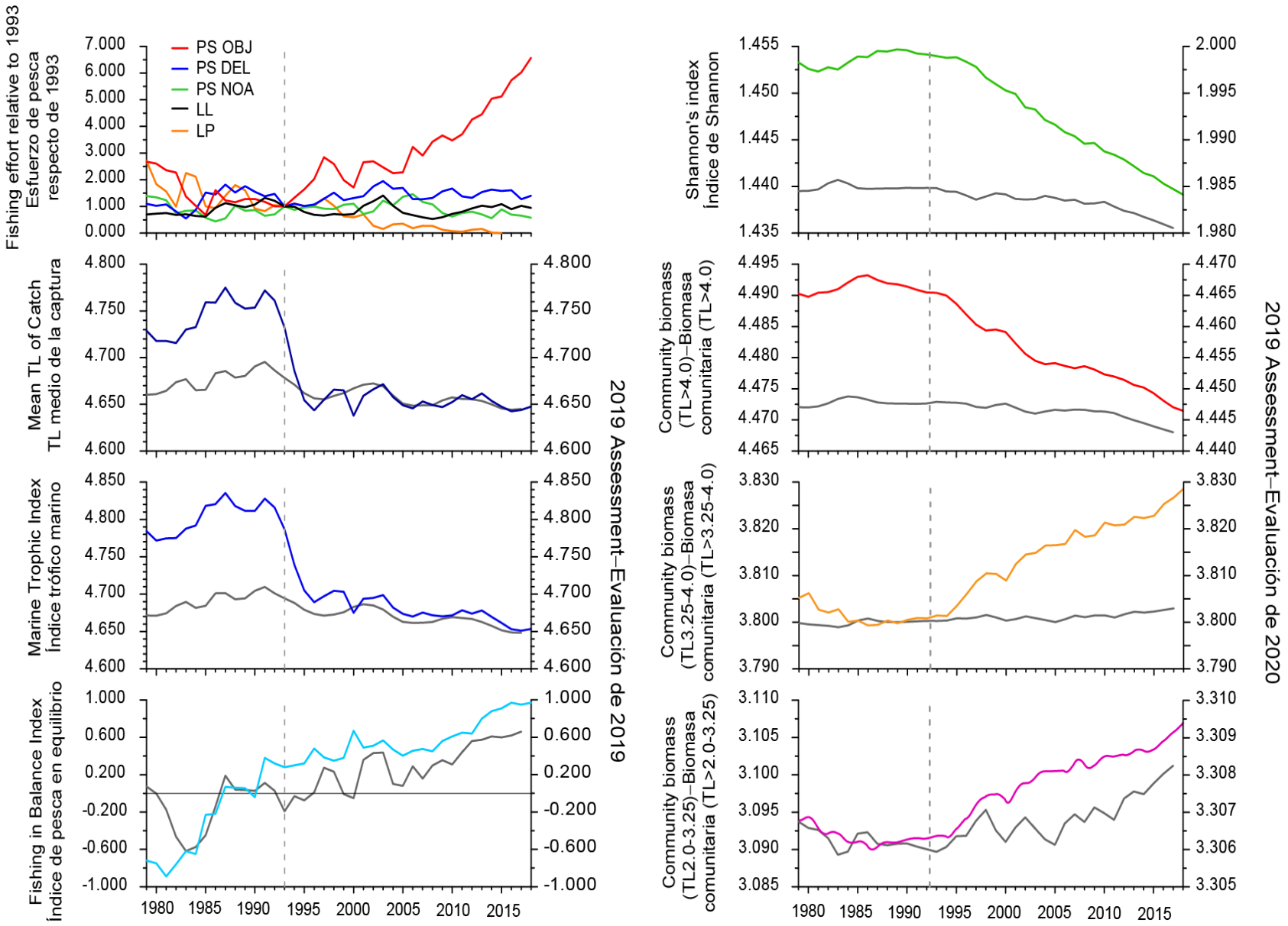
- Nominal fishing effort scaled from 1993
  - Coincidentally, start of the FAD fishery
  - ~7-fold increase in number of OBJ sets 1993-2018

Fishing-based indicators



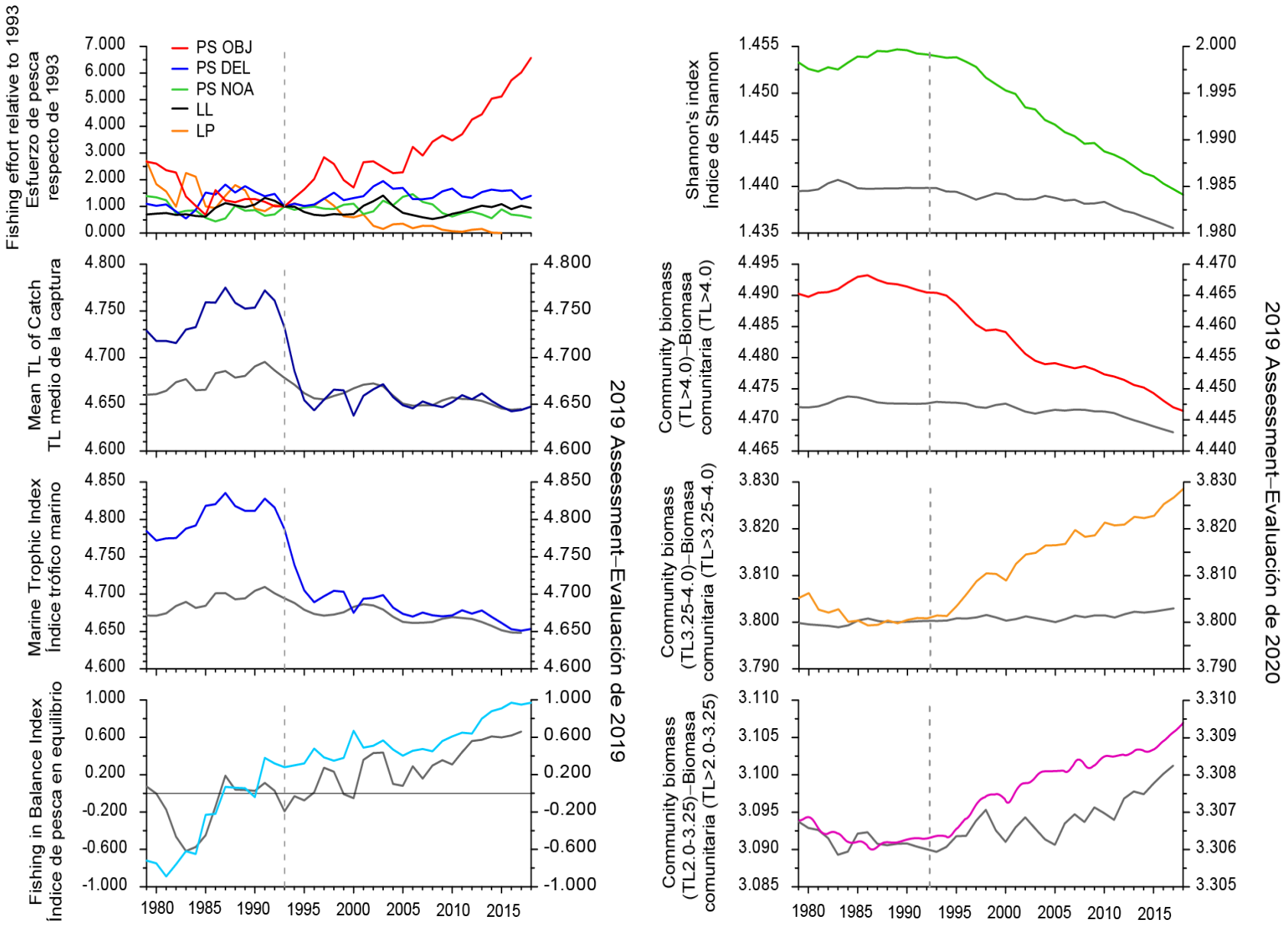
- Nominal fishing effort scaled from 1993
  - Coincidentally, start of the FAD fishery
  - ~7-fold increase in number of OBJ sets 1993-2018
- TL_c and MTI declined by 0.05 for 1991-2018
  - Change in TL_c of ≥ 0.1 per decade is significant
- FIB >0 since 1991
  - Indicates expansion of fishery, likely due to increasing catch of bycatch species

Community-based indicators



- Declining “evenness”
  - Changing relative biomass
- Alternating biomass trends by TL
  - Decline of predators (>4.0)
  - Increase of prey (3.25-4.0)
- Minor trophic cascade

Community-based indicators



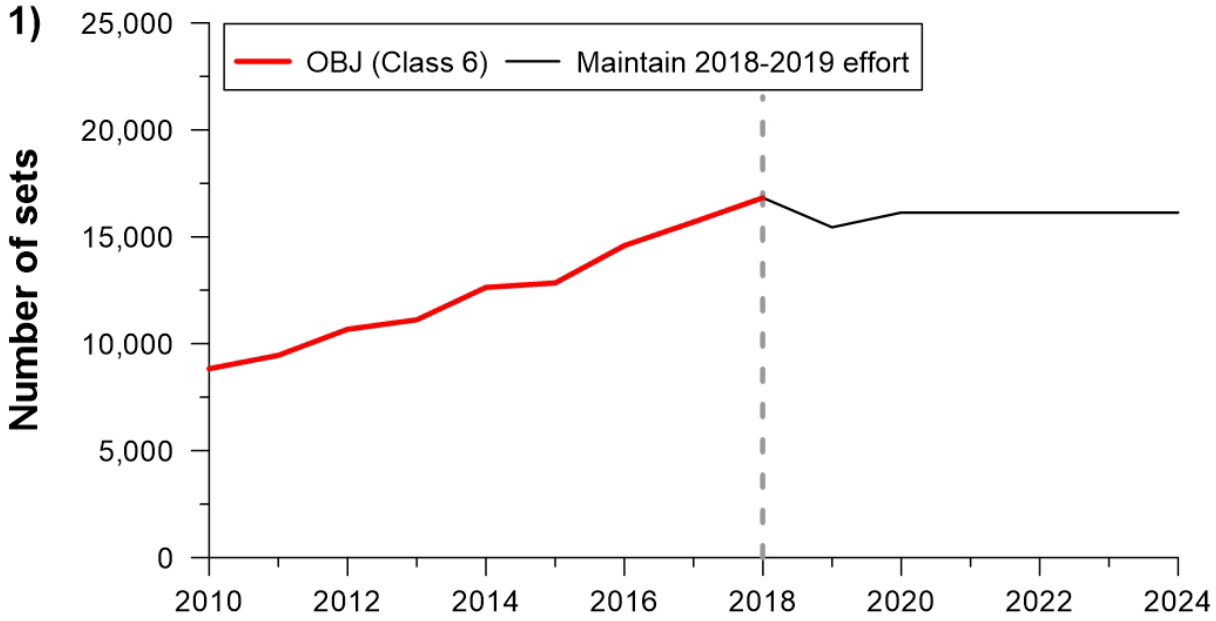
- Declining "evenness"
  - Changing relative biomass
- Alternating biomass trends by TL
  - Decline of predators (>4.0)
  - Increase of prey (3.25-4.0)
- Minor trophic cascade
- Continued trends, certainly requires monitoring

Results

Simulating the potential impacts of FAD fishing on key species and ecosystem structure

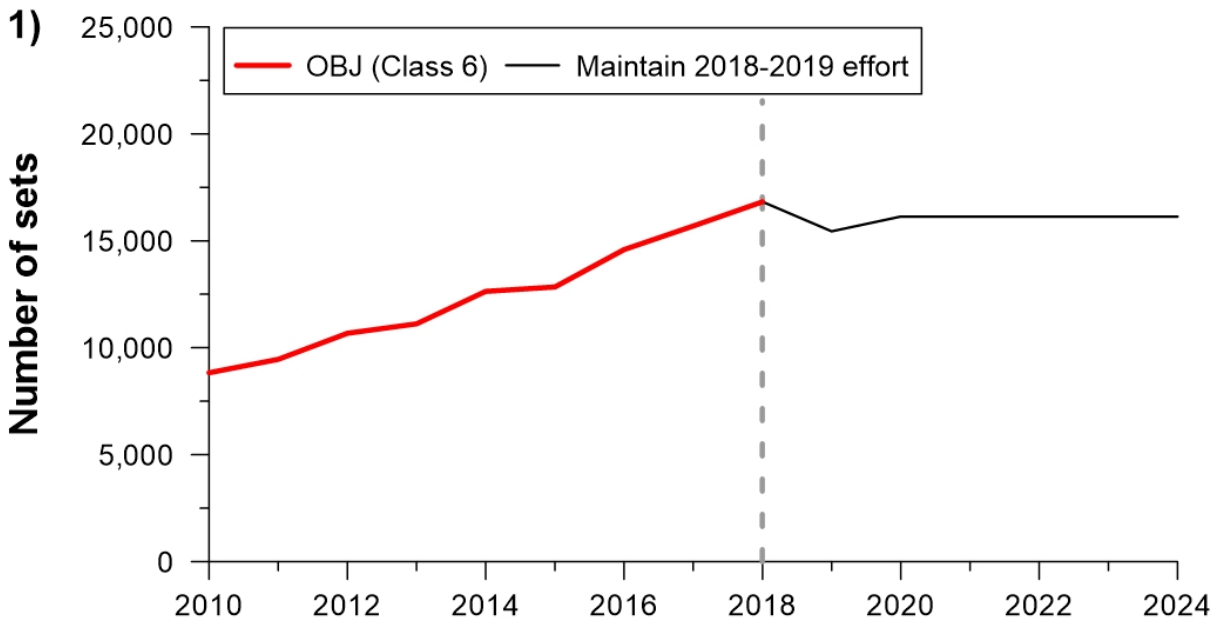
Modelled scenarios

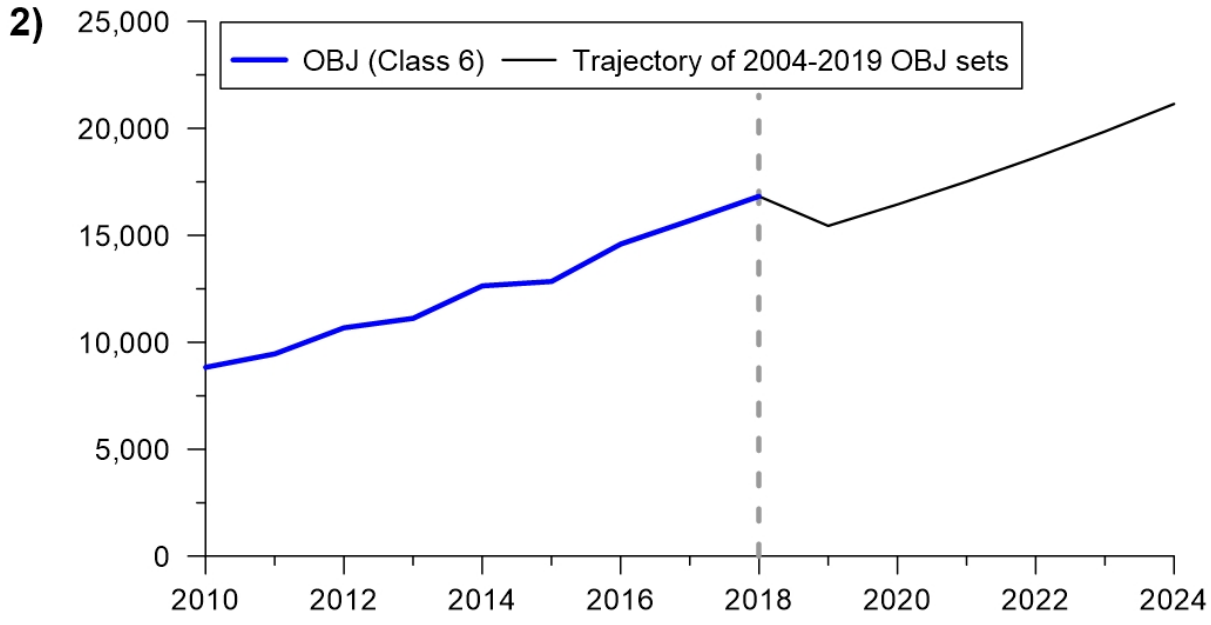
1. Average no. of OBJ sets for 2018-2019 maintained from 2018 to 2024
   - Effort for all other fisheries maintained at 2018 levels



Modelled scenarios

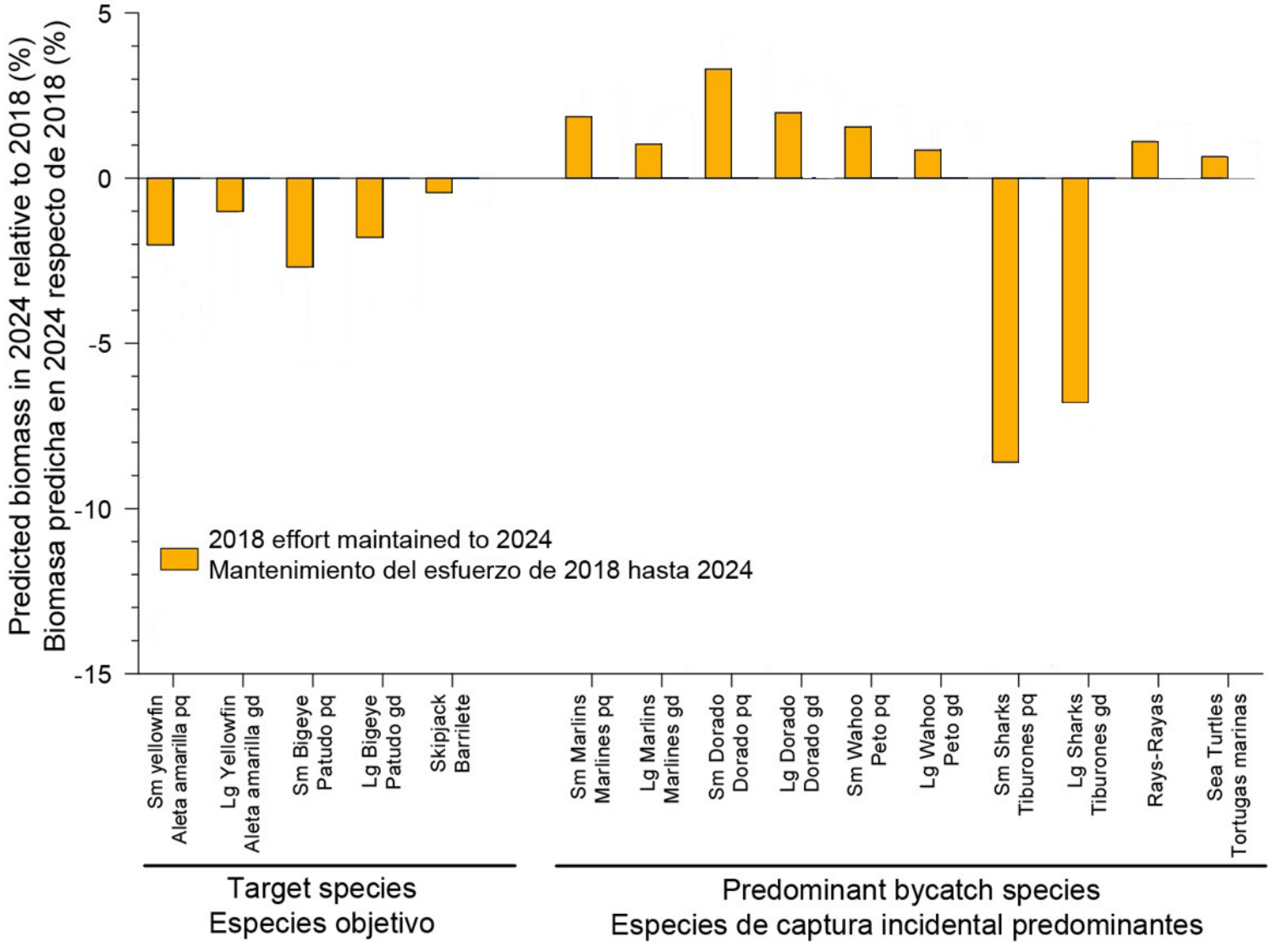
2. Increase OBJ sets following the trajectory from 2004-2019
   - Effort for all other fisheries maintained at 2018 levels





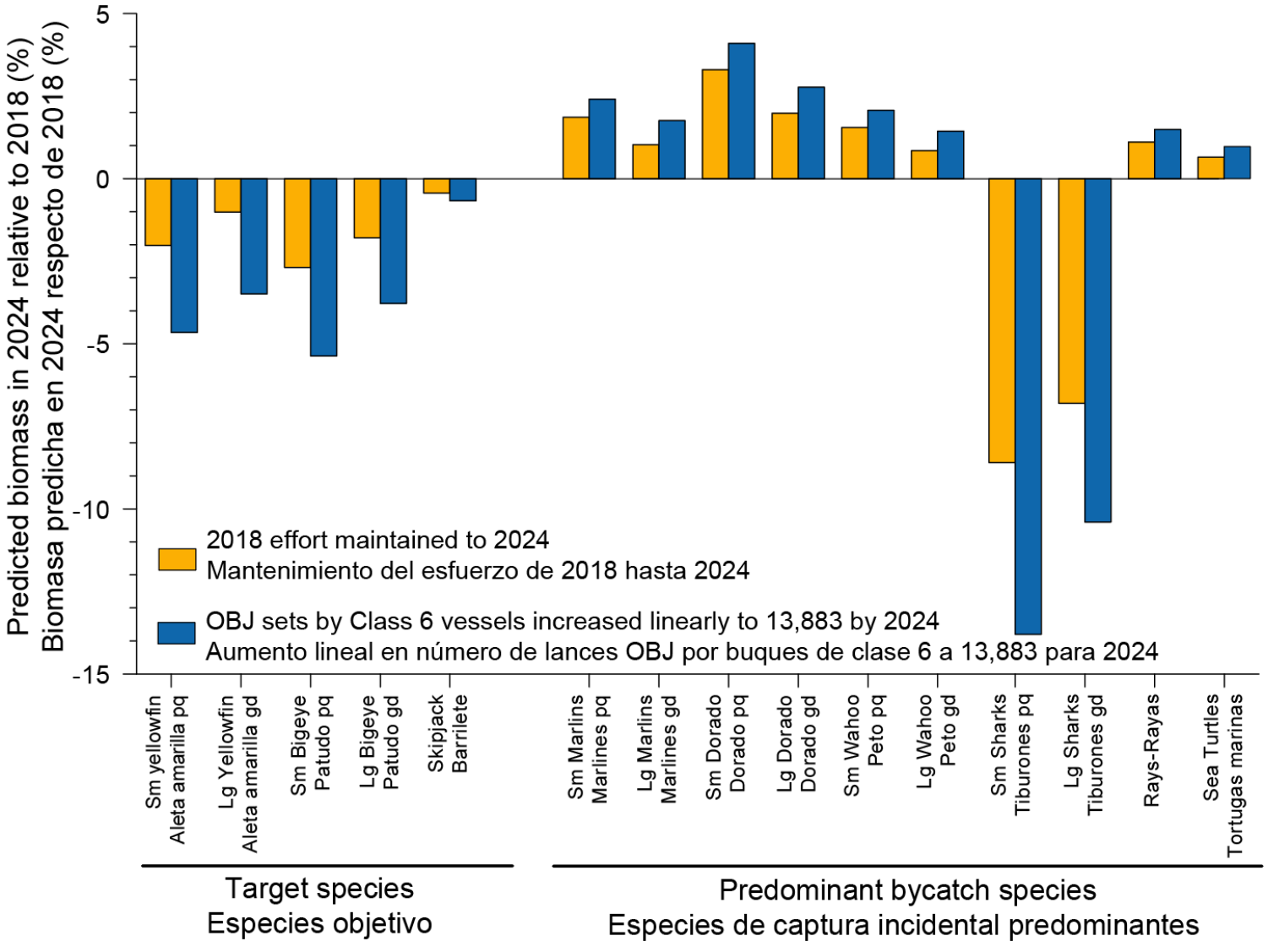
1) Maintain 2018/2019 effort

- Biomass of tunas ↓1-3%, retained bycatch ↑1-3%, sharks ↓7-9%



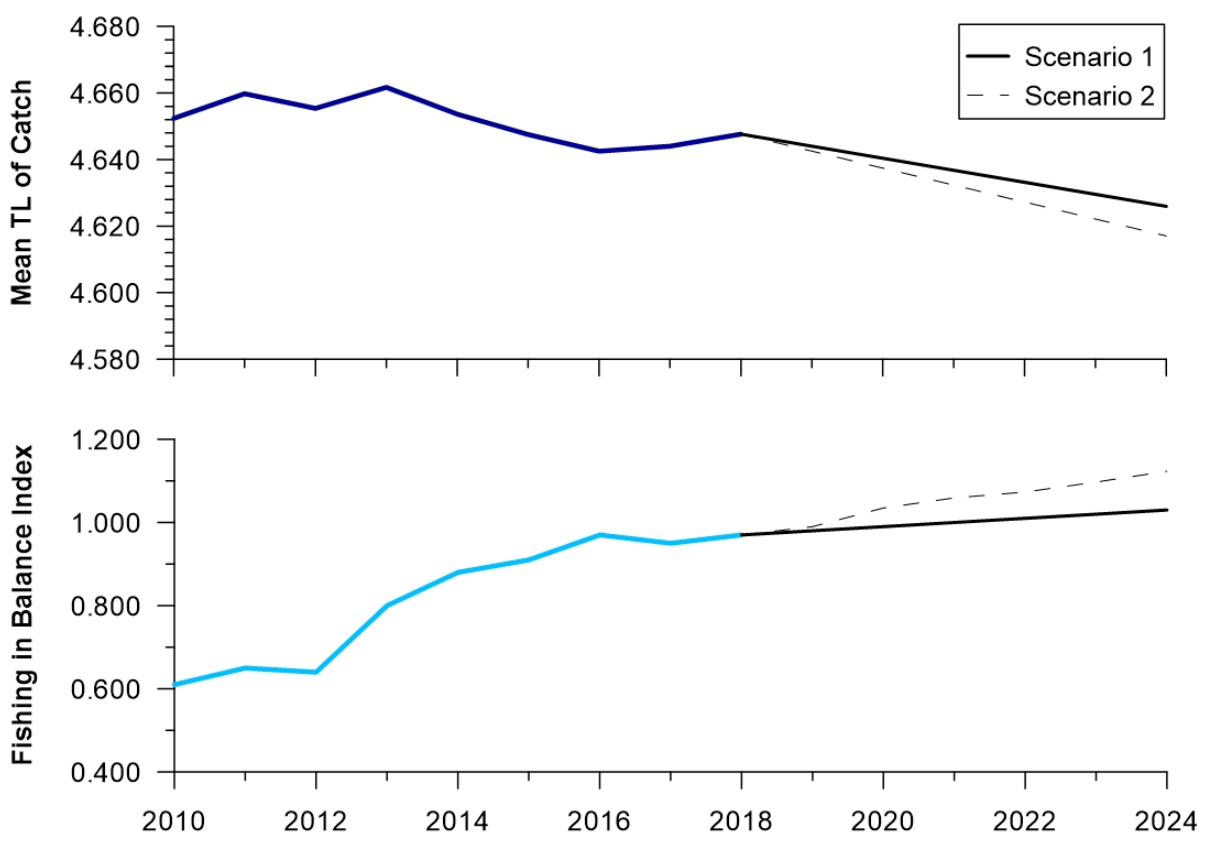
2) Increase OBJ effort

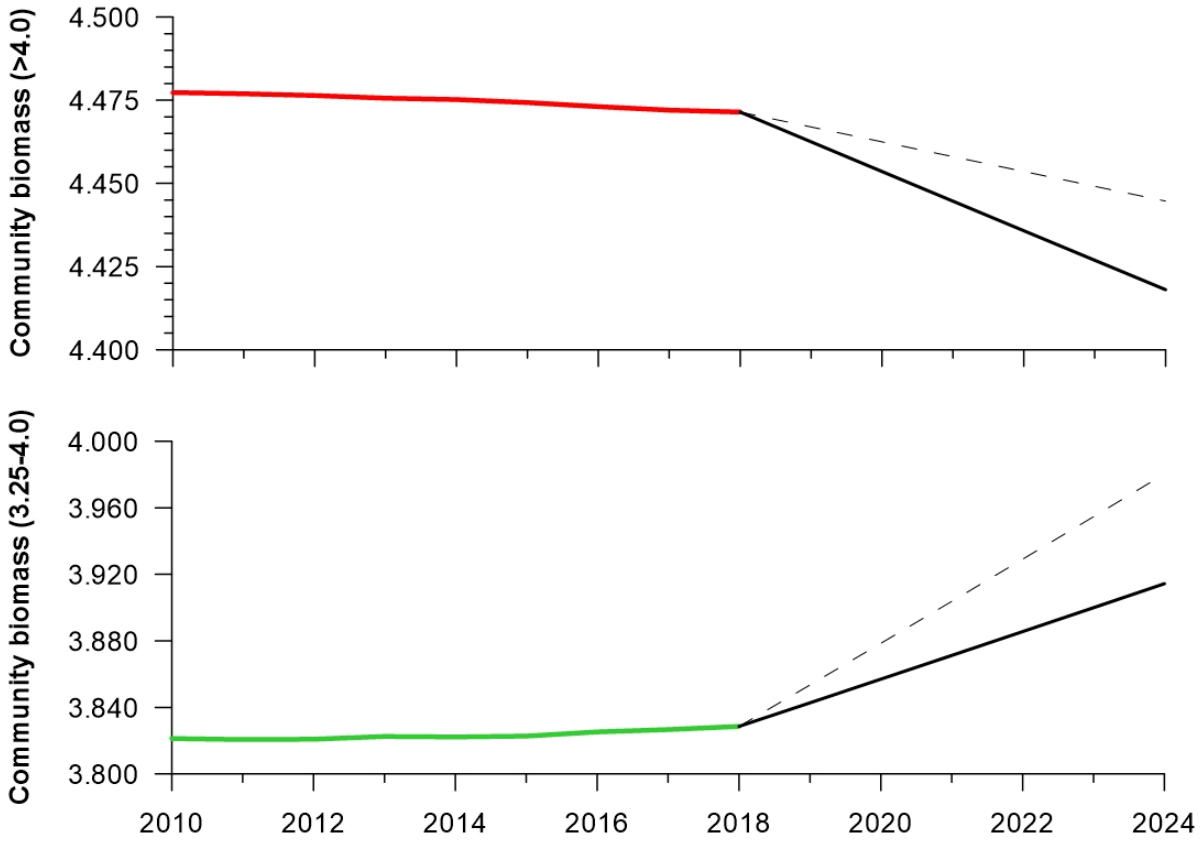
- Biomass of tunas ↓1-5%, retained bycatch ↑1-6%, sharks ↓11-14%



Changes to ecosystem structure

- Continued decline of TLc & TL>4.0; increase FIB & TL 3.25





Summary

- ETP-21 improved realism of the ETP ecosystem and calibration improved reliability of forecasts by reproducing past population trends.
- The structure of the ETP substantial changed over the history of the EPO tuna fishery, and more pessimistic than 2019 assessment.
- Changes most significant since the early 1990s coinciding with the increase in OBJ sets, increasing by ~50% every 5 years; 7-fold since 1993.
- Maintaining 2018-2019 effort levels resulted in biomass declines of target species, but especially small and large sharks.
- Increase in OBJ effort predicted to result in further biomass declines for tuna and sharks and compromise the ETP structure.

Future research

- If ETP-21 or new model used, data improvements are required
- Data for catch (retained and discards) & effort (SAC-12-09)
  - Longline (especially shallow *vs*. deep sets)
  - Purse-seine class 1-5 by set type
  - Coastal 'artisanal' fleets (longline & gillnets)
- Foundation of the model is diet data from early 1990s
  - EPO has experienced some of the strongest El Nino events on record
  - FAD impacts may have altered predator-prey dynamics
- EPO ecological sampling program required to update diet matrix and key model parameters (*e.g*. consumption rates, SAC-10 INF-E)

CIAT

IATTC

Questions?