

## **Annex I**

# **Biological Simulation of Management Scenarios for the Development of Italian Demersal Trawl Fishery Management Plans for the 2025–2030 Period**

Authors: Armelloni, E., Arneri E., Angelini, S., Fiorentino, F., Falsone, F., Mannini, A., Ferrà, C., Scarcella.G.

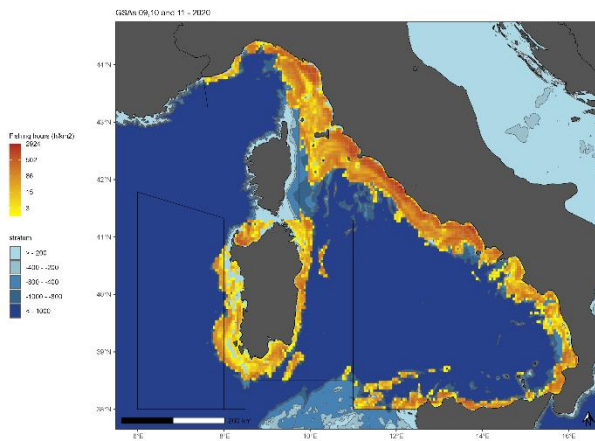
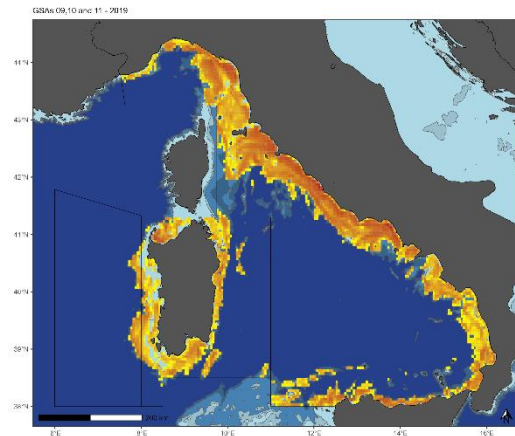
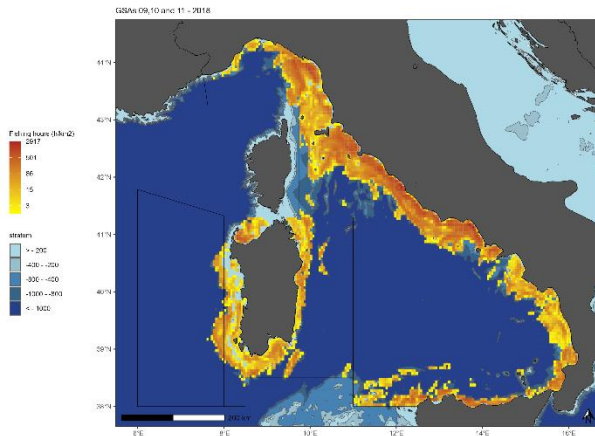
CNR-IRBIM

## Results

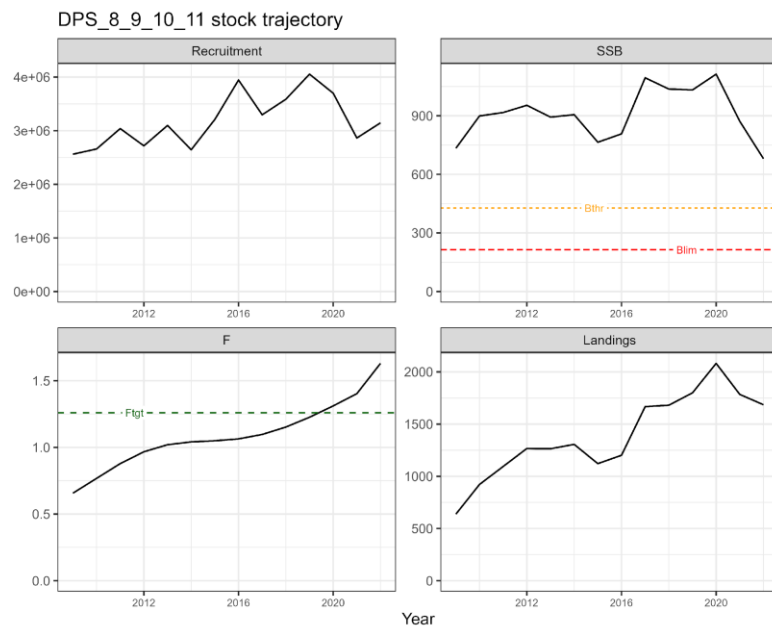
### Tyrrhenian Sea

Weak stock: ARS\_9\_10\_11

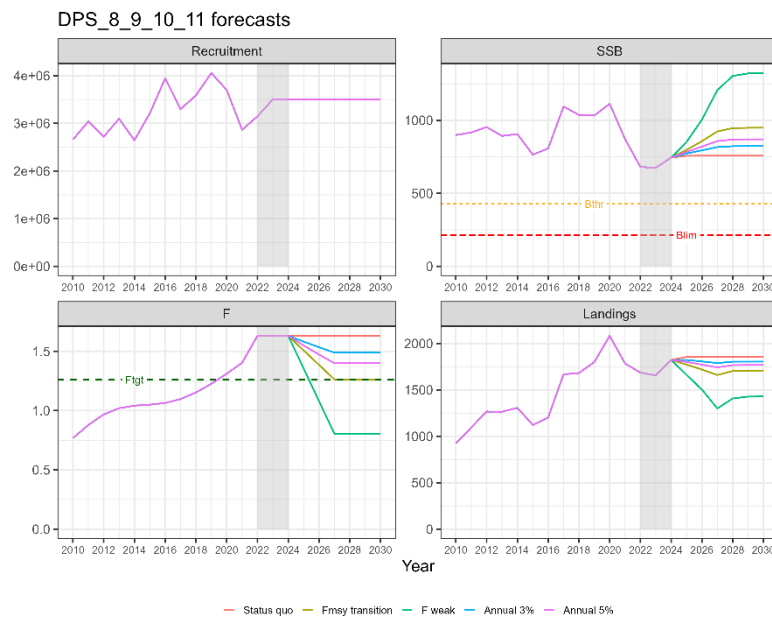
### Fishing effort displacement 2018-2020



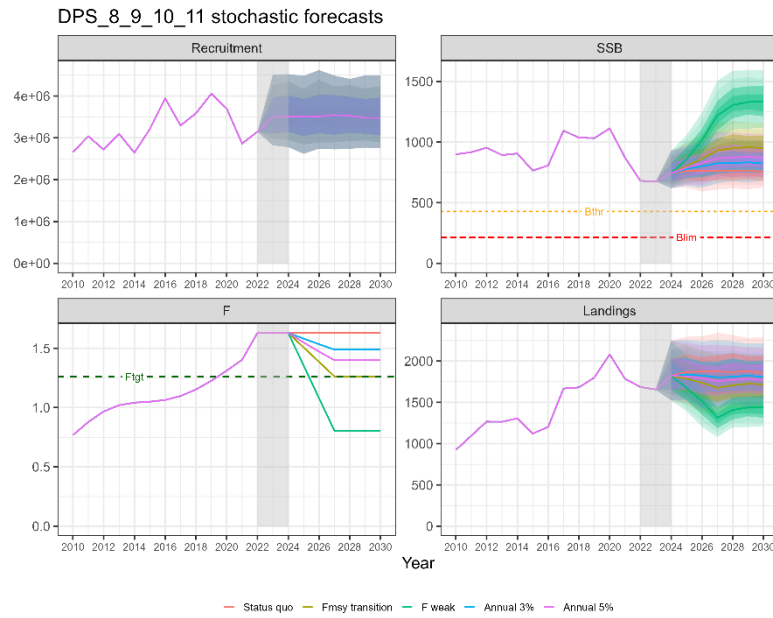
## DPS\_8\_9\_10\_11



## DPS\_8\_9\_10\_11 Stock trajectory from most recent stock assessment



## DPS\_8\_9\_10\_11 Deterministic forecast

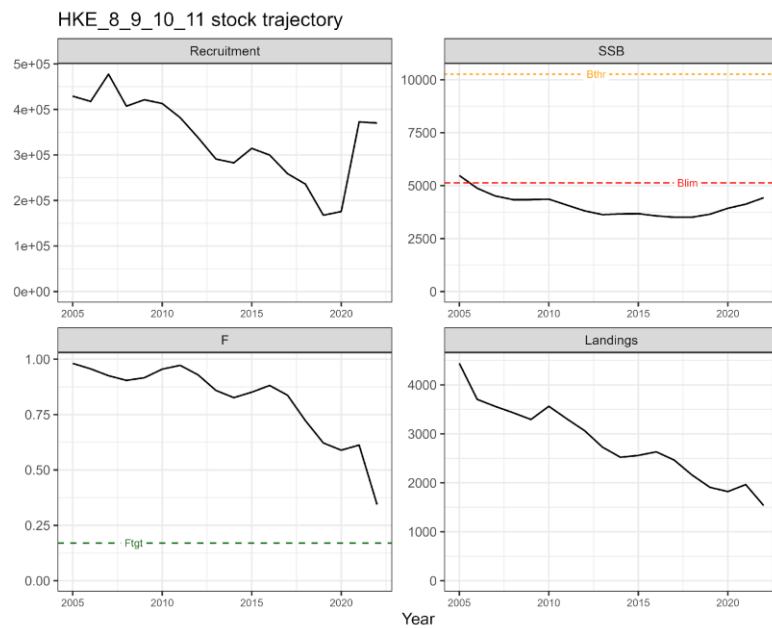


### *DPS\_8\_9\_10\_11 Stochastic forecast*

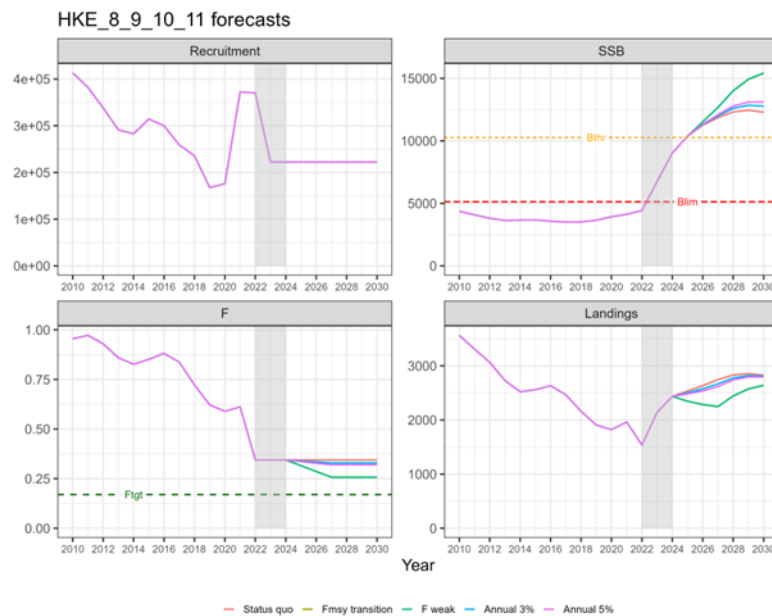
#### *Forecast results by scenario in 2030*

| Scenario        | SSB (tons) | Fbar  | Total Catches (tons) | Catches from Italian trawlers (tons) |
|-----------------|------------|-------|----------------------|--------------------------------------|
| Status quo      | 757        | 1.630 | 1857                 | 1842                                 |
| Fmsy transition | 949        | 1.263 | 1708                 | 1693                                 |
| F weak          | 1324       | 0.805 | 1430                 | 1415                                 |
| Annual 3%       | 823        | 1.489 | 1805                 | 1790                                 |
| Annual 5%       | 870        | 1.399 | 1768                 | 1753                                 |

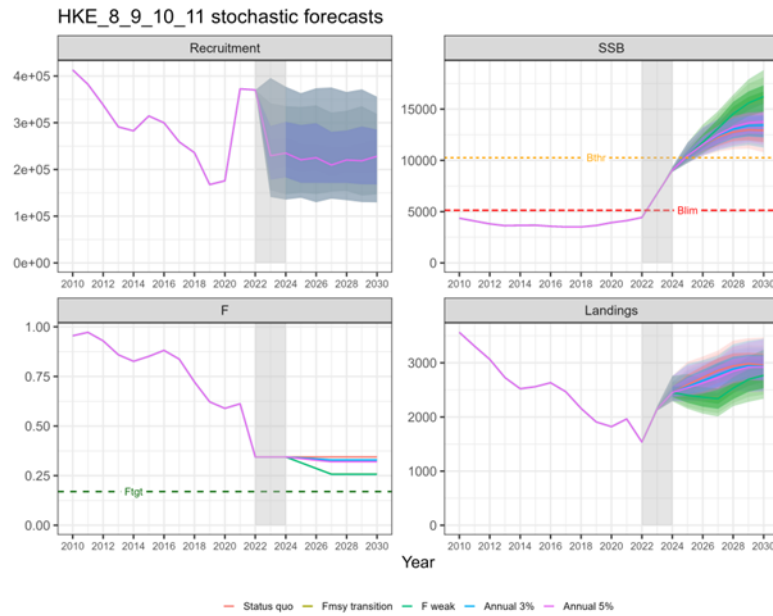
## HKE\_8\_9\_10\_11



*HKE\_8\_9\_10\_11 Stock trajectory from most recent stock assessment*



*HKE\_8\_9\_10\_11 Deterministic forecast*

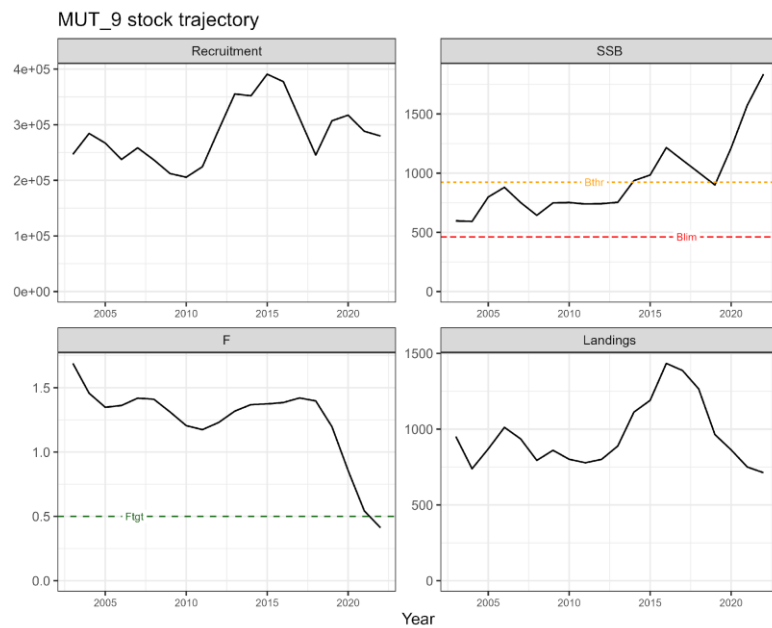


### *HKE\_8\_9\_10\_11 Stochastic forecast*

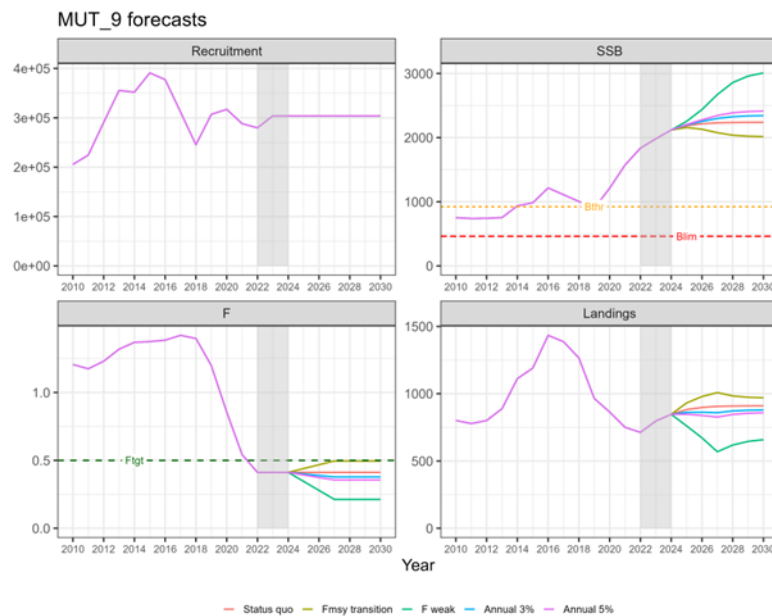
#### *Forecast results by scenario in 2030*

| Scenario        | SSB (tons) | Fbar  | Total Catches (tons) | Catches from Italian trawlers (tons) |
|-----------------|------------|-------|----------------------|--------------------------------------|
| Status quo      | 12294      | 0.344 | 2828                 | 1403                                 |
| Fmsy transition | 15404      | 0.258 | 2642                 | 1217                                 |
| F weak          | 15429      | 0.257 | 2640                 | 1215                                 |
| Annual 3%       | 12779      | 0.329 | 2810                 | 1385                                 |
| Annual 5%       | 13099      | 0.320 | 2796                 | 1371                                 |

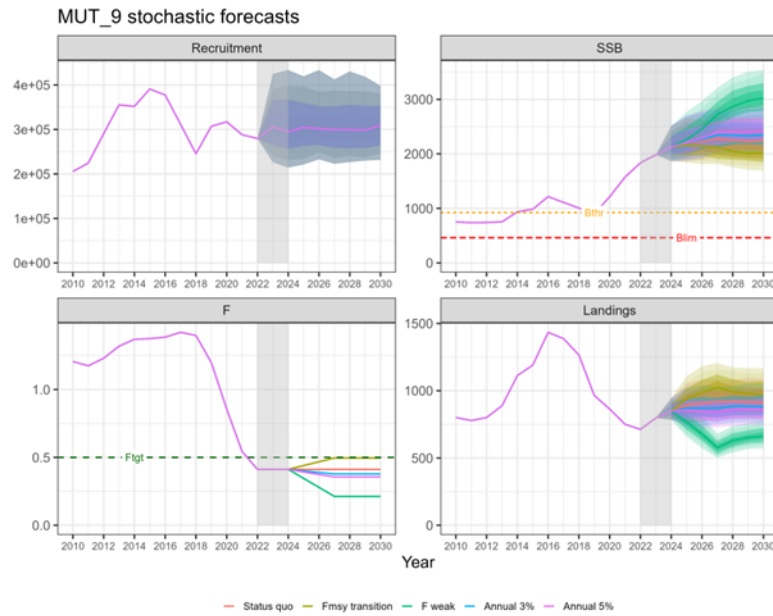
## MUT\_9



*MUT\_9 Stock trajectory from most recent stock assessment*



*MUT\_9 Deterministic forecast*

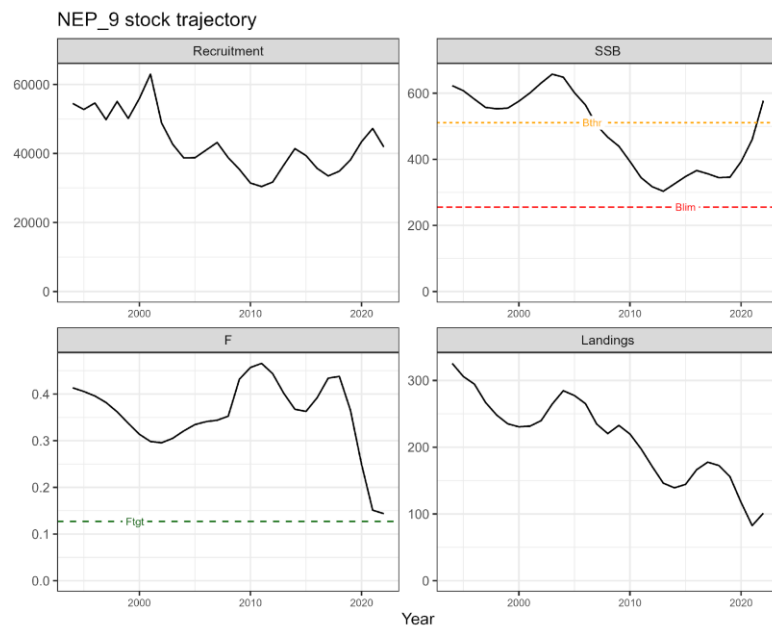


### *MUT\_9 Stochastic forecast*

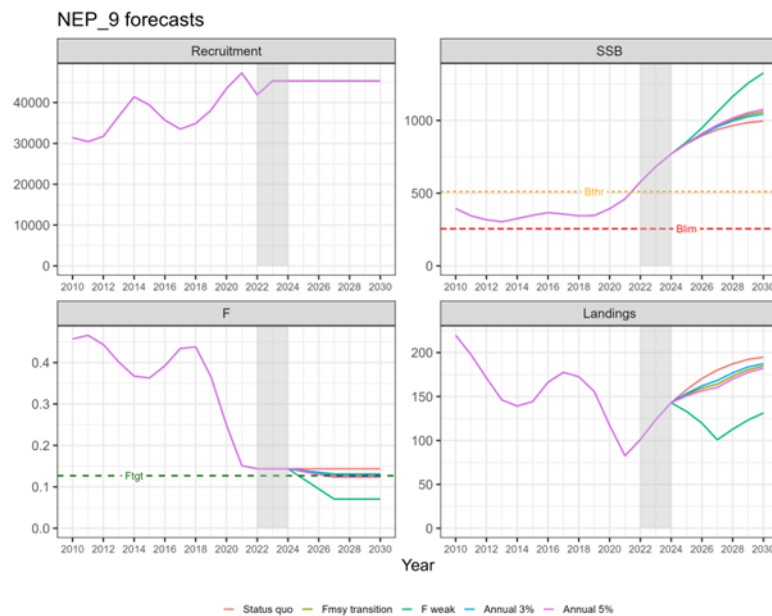
### *Forecast results by scenario in 2030*

| Scenario        | SSB (tons) | Fbar  | Total Catches (tons) | Catches from Italian trawlers (tons) |
|-----------------|------------|-------|----------------------|--------------------------------------|
| Status quo      | 2238       | 0.412 | 910                  | 863                                  |
| Fmsy transition | 2016       | 0.495 | 970                  | 923                                  |
| F weak          | 3009       | 0.213 | 659                  | 612                                  |
| Annual 3%       | 2343       | 0.378 | 880                  | 833                                  |
| Annual 5%       | 2414       | 0.356 | 858                  | 811                                  |

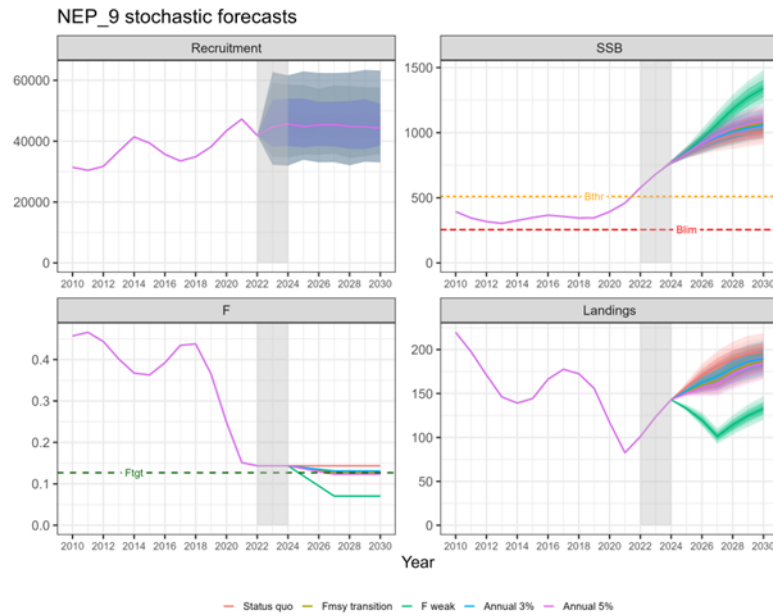
## NEP\_9



### NEP\_9 Stock trajectory from most recent stock assessment



### NEP\_9 Deterministic forecast



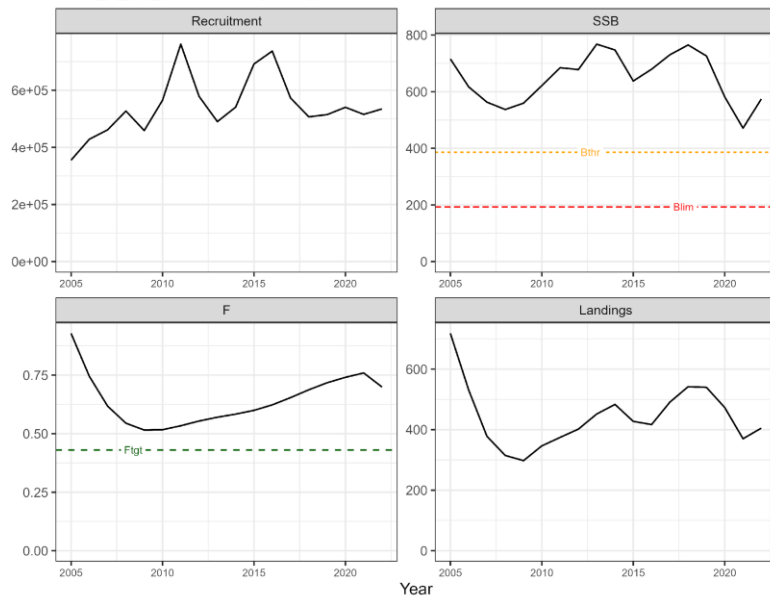
### NEP\_9 Stochastic forecast

### Forecast results by scenario in 2030

| Scenario        | SSB (tons) | Fbar  | Total Catches (tons) | Catches from Italian trawlers (tons) |
|-----------------|------------|-------|----------------------|--------------------------------------|
| Status quo      | 996        | 0.144 | 195                  | 195                                  |
| Fmsy transition | 1061       | 0.127 | 185                  | 185                                  |
| F weak          | 1326       | 0.070 | 131                  | 131                                  |
| Annual 3%       | 1044       | 0.131 | 188                  | 188                                  |
| Annual 5%       | 1076       | 0.123 | 182                  | 182                                  |

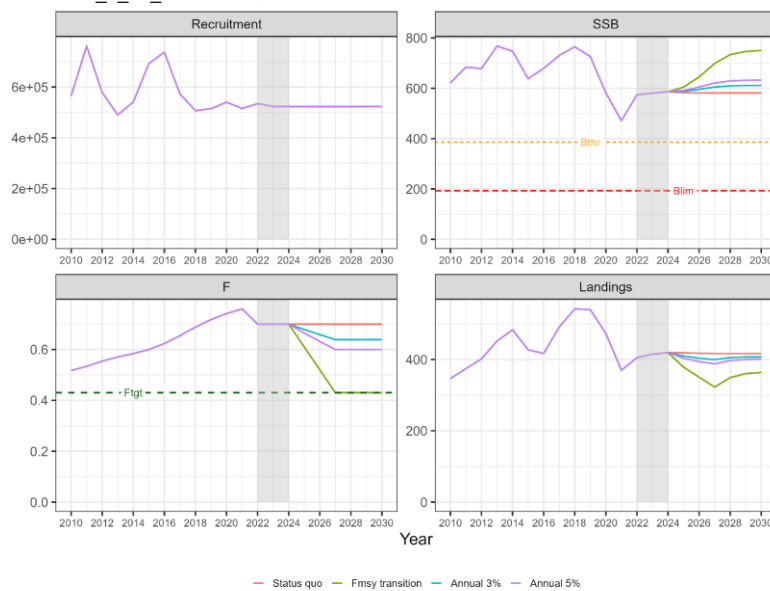
## ARS\_9\_10\_11

ARS\_9\_10\_11 stock trajectory

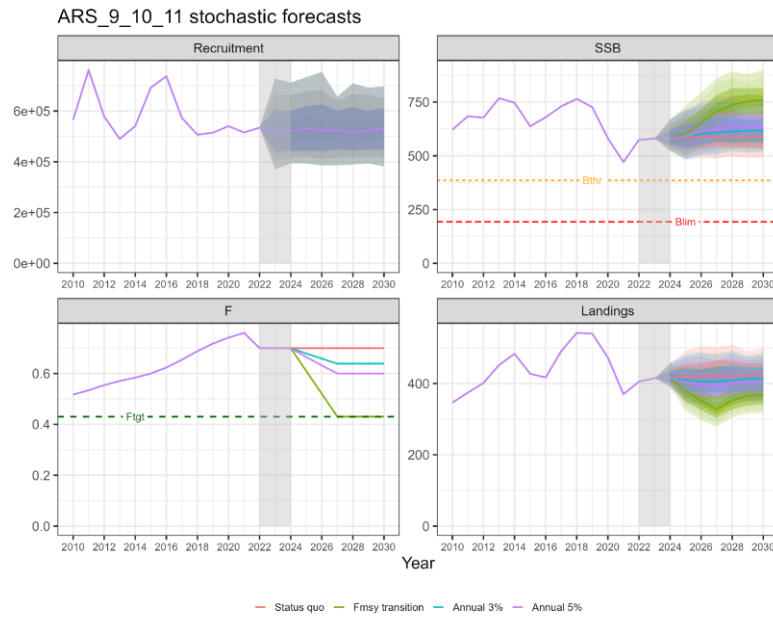


ARS\_9\_10\_11 Stock trajectory from most recent stock assessment

ARS\_9\_10\_11 forecasts



ARS\_9\_10\_11 Deterministic forecast

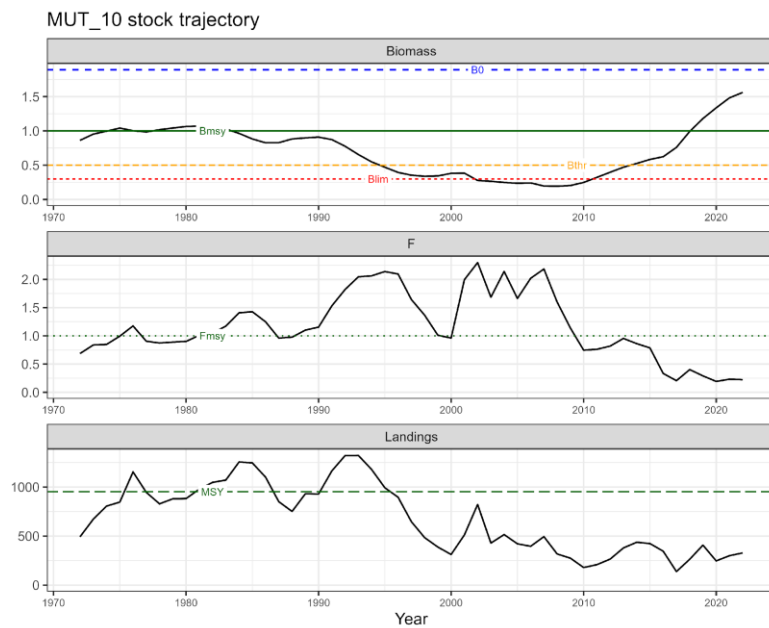


### ARS\_9\_10\_11 Stochastic forecast

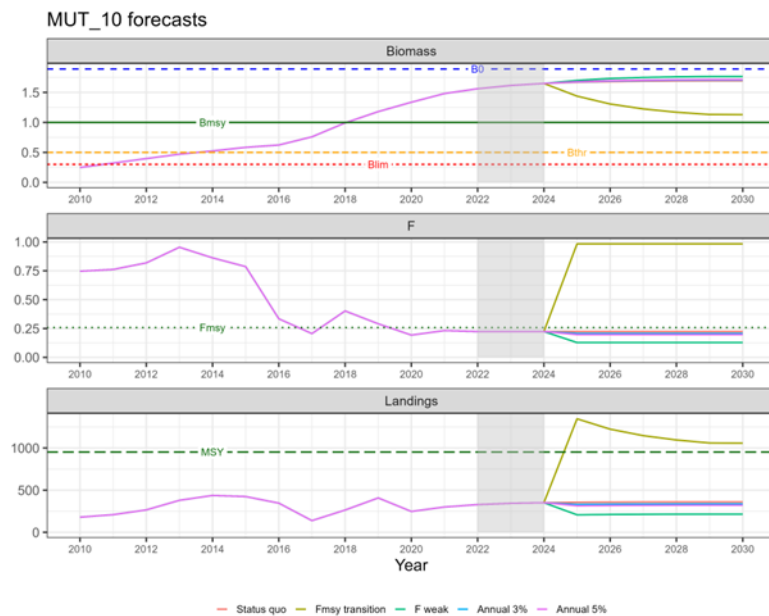
### Forecast results by scenario in 2030

| Scenario        | SSB (tons) | Fbar  | Total Catches (tons) | Catches from Italian trawlers (tons) |
|-----------------|------------|-------|----------------------|--------------------------------------|
| Status quo      | 581        | 0.699 | 417                  | 416                                  |
| Fmsy transition | 750        | 0.431 | 364                  | 363                                  |
| Annual 3%       | 611        | 0.638 | 407                  | 406                                  |
| Annual 5%       | 632        | 0.600 | 401                  | 400                                  |

## MUT\_10



*MUT\_10 Stock trajectory from most recent stock assessment*



*MUT\_10 Deterministic forecast*

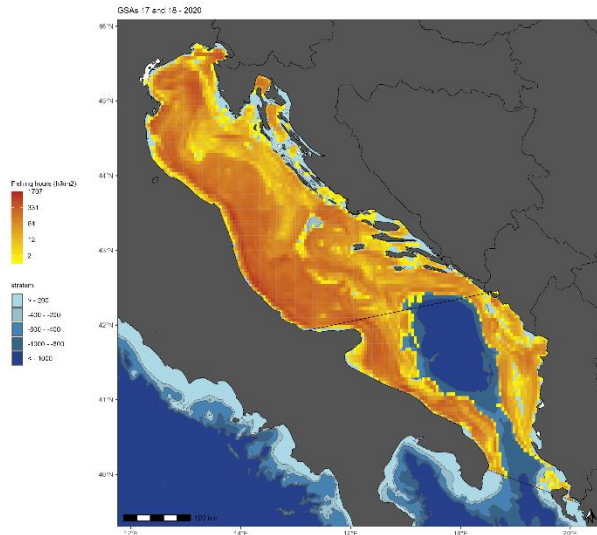
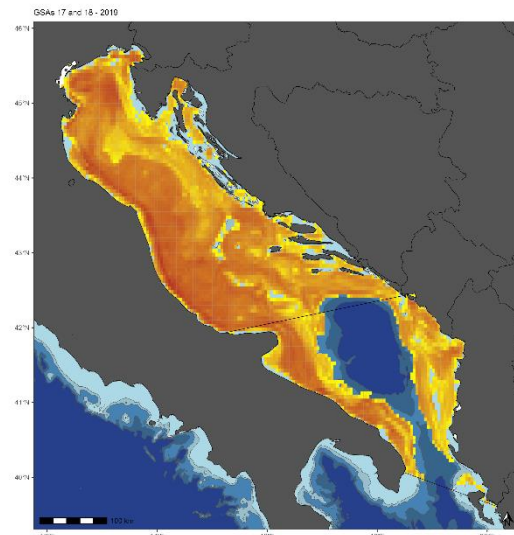
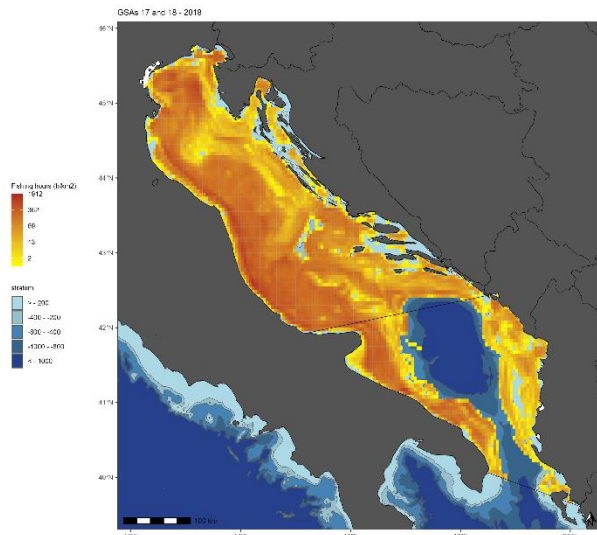
*Forecast results by scenario in 2030*

| Scenario        | Total biomass (tons) | Fbar  | Total Catches (tons) | Catches from Italian trawlers (tons) |
|-----------------|----------------------|-------|----------------------|--------------------------------------|
| Status quo      | 6239                 | 0.223 | 360                  | 301                                  |
| Fmsy transition | 4162                 | 0.983 | 1058                 | 1000                                 |
| F weak          | 6503                 | 0.128 | 215                  | 157                                  |
| Annual 3%       | 6284                 | 0.207 | 336                  | 278                                  |
| Annual 5%       | 6313                 | 0.197 | 321                  | 263                                  |

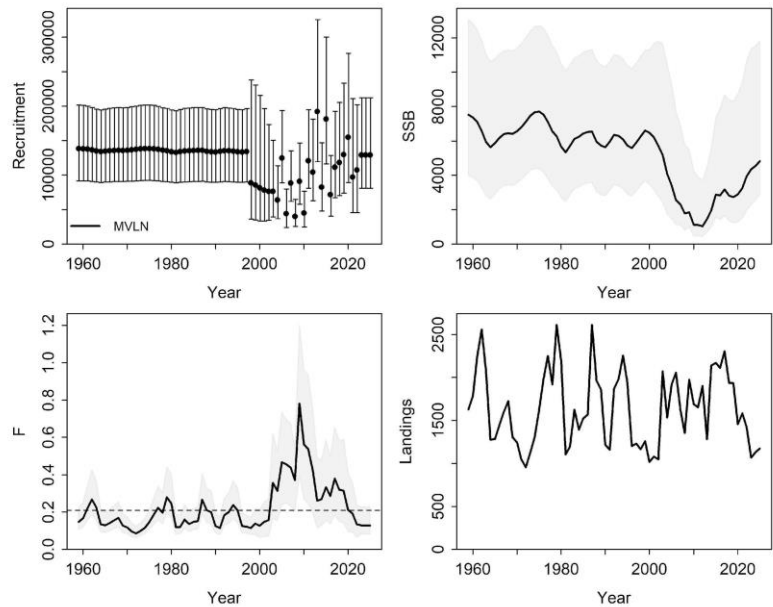
## Adriatic Sea

Weak stock: HKE\_17\_18

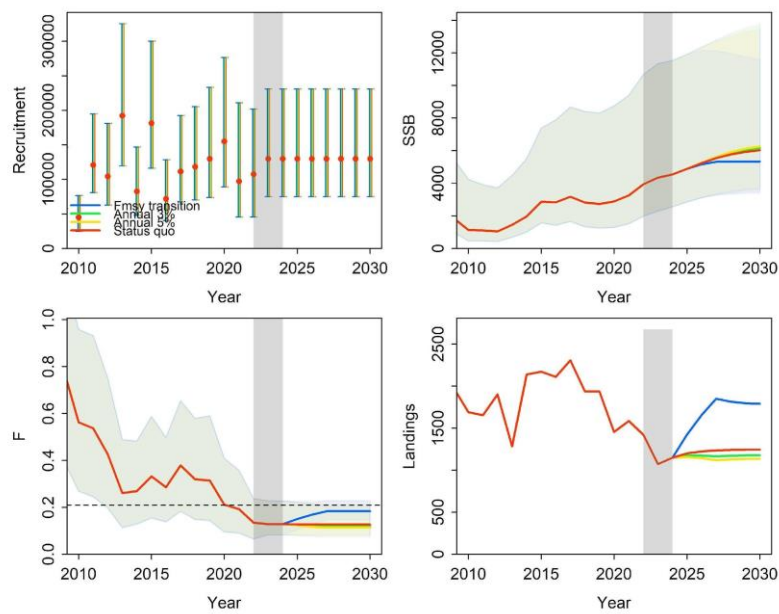
### Fishing effort displacement 2018-2020



SOL\_17



SOL\_17 Stock trajectory from most recent stock assessment



SOL\_17 Deterministic forecast

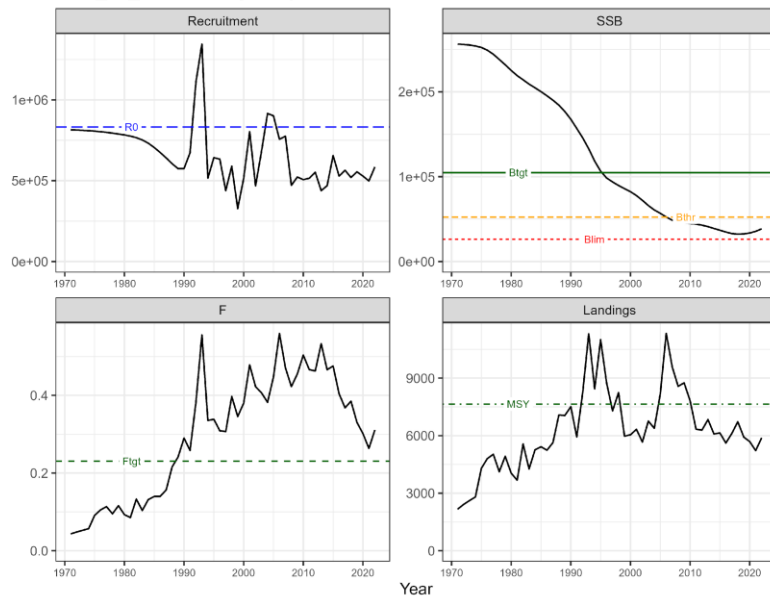
Forecast results by scenario in 2030

| Scenario  | SSB (tons) | Fbar  | Total Catches (tons) | Catches from Italian trawlers (tons) |
|-----------|------------|-------|----------------------|--------------------------------------|
| Annual 3% | 6170       | 0.119 | 1173                 | 842                                  |

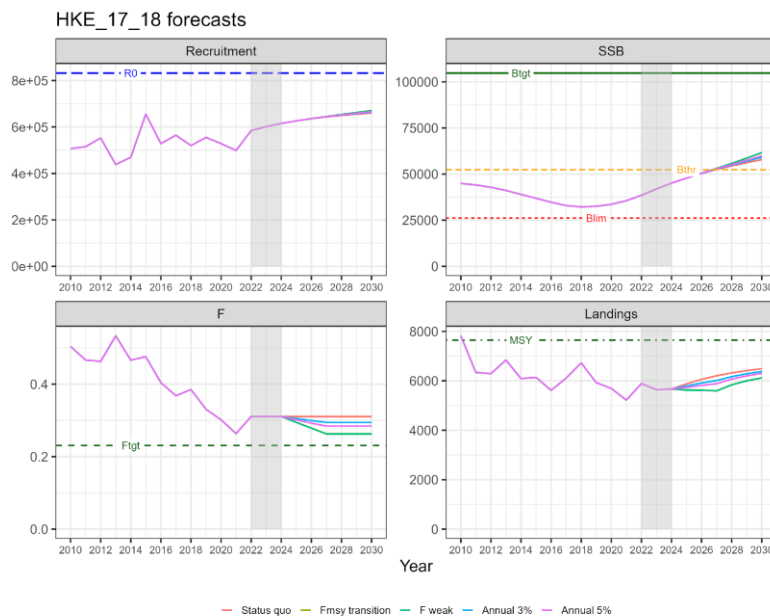
| Scenario        | SSB (tons) | Fbar  | Total Catches (tons) | Catches from Italian trawlers (tons) |
|-----------------|------------|-------|----------------------|--------------------------------------|
| Annual 5%       | 6263       | 0.114 | 1130                 | 796                                  |
| Fmsy transition | 5336       | 0.183 | 1801                 | 1478                                 |
| Status quo      | 6028       | 0.127 | 1239                 | 912                                  |

## HKE\_17\_18

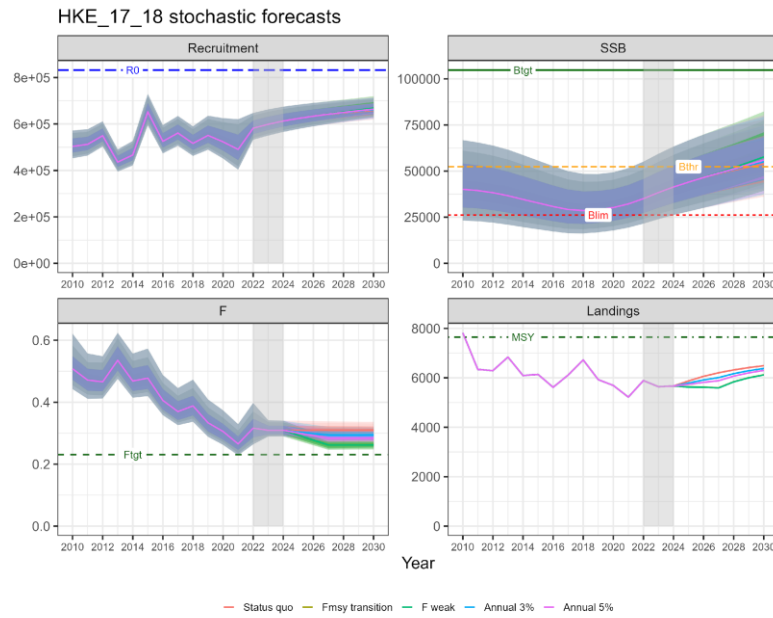
HKE\_17\_18 stock trajectory



HKE\_17\_18 Stock trajectory from most recent stock assessment



HKE\_17\_18 Deterministic forecast

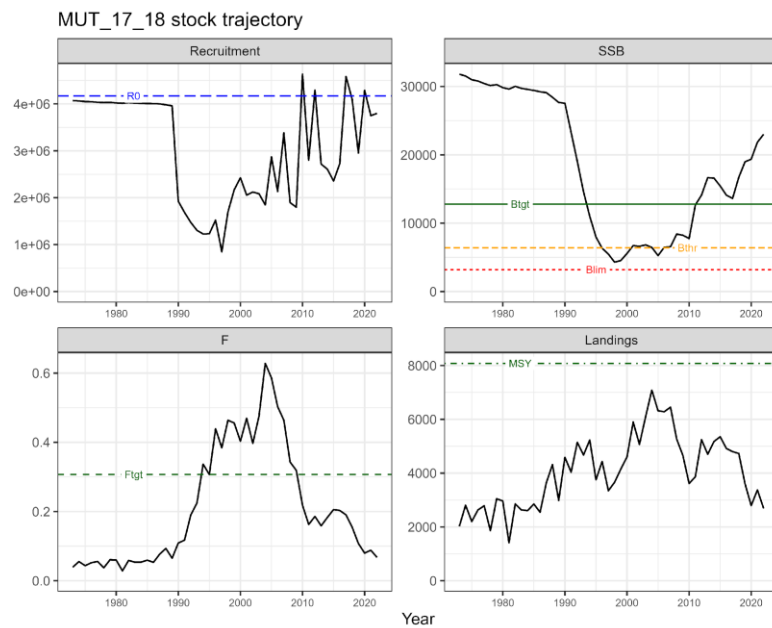


### *HKE\_17\_18 Stochastic forecast*

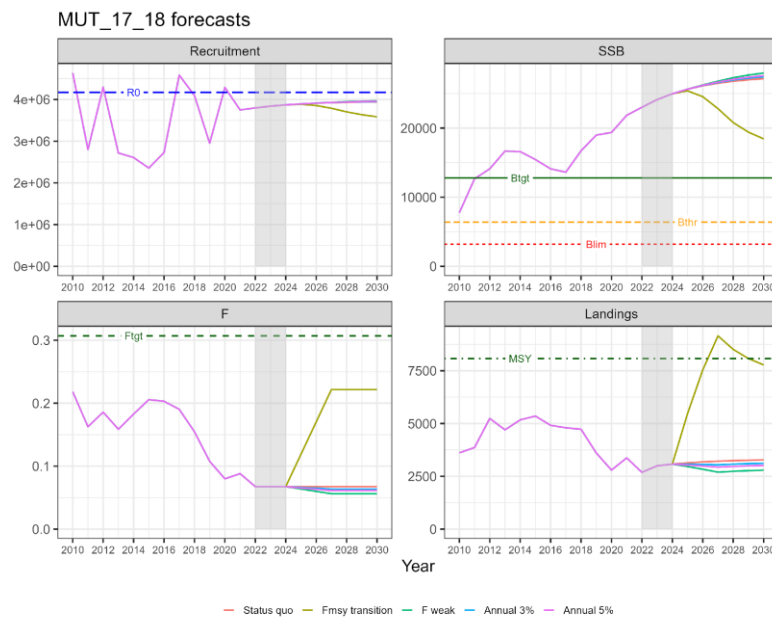
### *Forecast results by scenario in 2030*

| Scenario        | SSB (tons) | Fbar  | Total Catches (tons) | Catches from Italian trawlers (tons) |
|-----------------|------------|-------|----------------------|--------------------------------------|
| Status quo      | 57828      | 0.310 | 6489                 | 3683                                 |
| Fmsy transition | 61612      | 0.263 | 6121                 | 3010                                 |
| Annual 3%       | 59064      | 0.294 | 6377                 | 3472                                 |
| Annual 5%       | 59885      | 0.284 | 6300                 | 3330                                 |

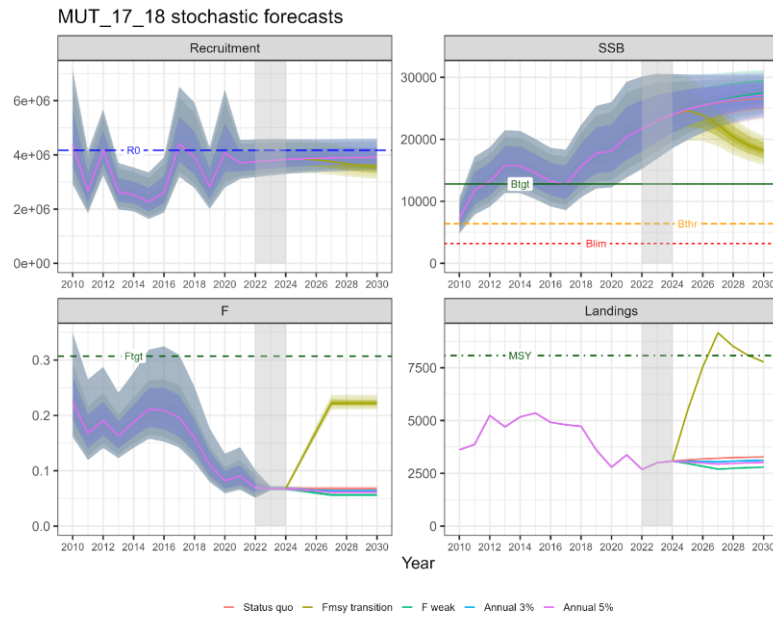
## MUT\_17\_18



### *MUT\_17\_18 Stock trajectory from most recent stock assessment*



### *MUT\_17\_18 Deterministic forecast*

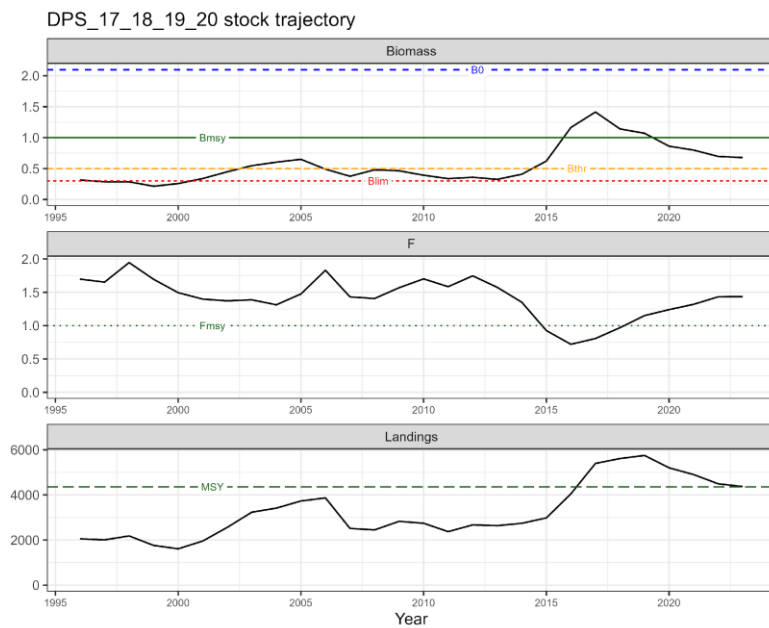


### *MUT\_17\_18 Stochastic forecast*

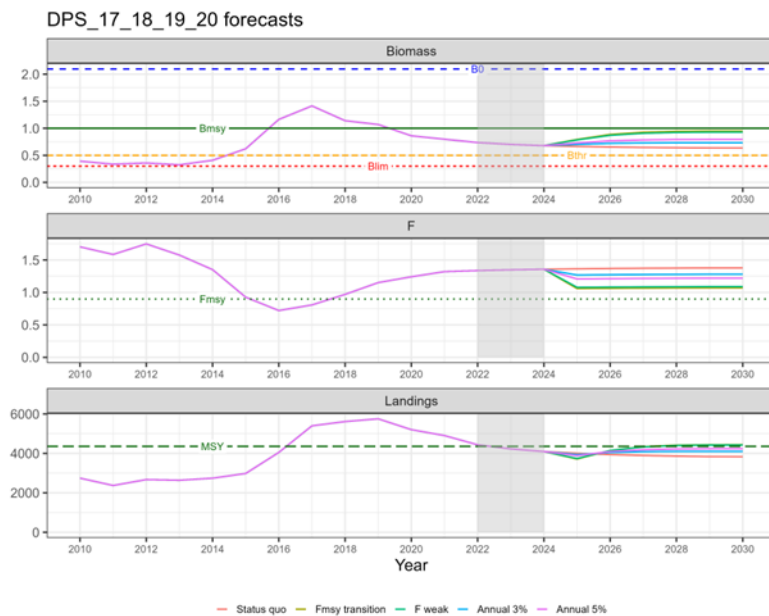
#### *Forecast results by scenario in 2030*

| Scenario        | SSB (tons) | Fbar  | Total Catches (tons) | Catches from Italian trawlers (tons) |
|-----------------|------------|-------|----------------------|--------------------------------------|
| Status quo      | 27146      | 0.068 | 3277                 | 2163                                 |
| Fmsy transition | 18444      | 0.222 | 7776                 | 7025                                 |
| F weak          | 27963      | 0.056 | 2791                 | 1643                                 |
| Annual 3%       | 27418      | 0.064 | 3117                 | 1992                                 |
| Annual 5%       | 27592      | 0.061 | 3014                 | 1881                                 |

## DPS\_17\_18\_19\_20



*DPS\_17\_18\_19\_20 Stock trajectory from most recent stock assessment*



*DPS\_17\_18\_19\_20 Deterministic forecast*

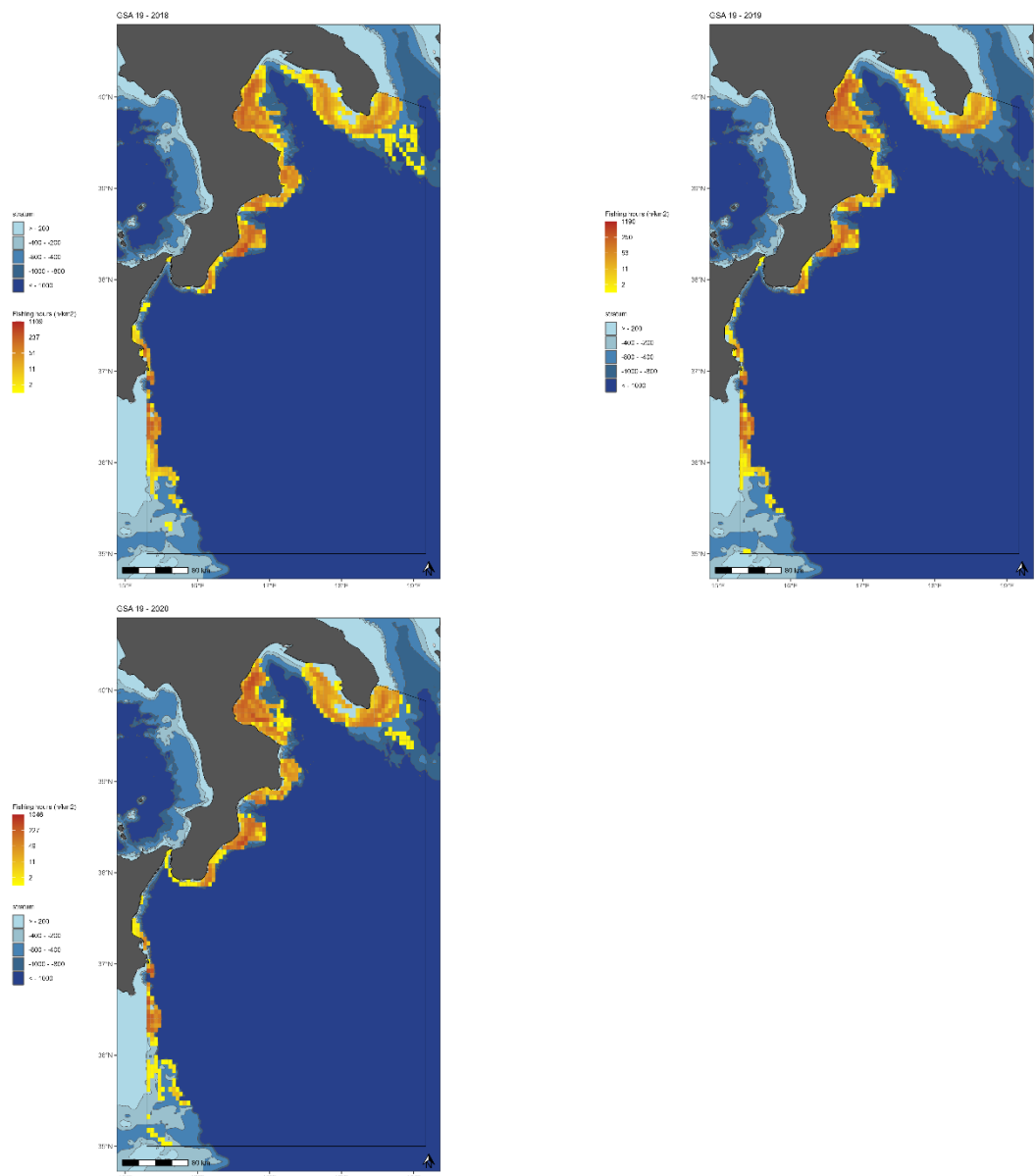
*Forecast results by scenario in 2030*

| Scenario        | Total biomass (tons) | Fbar  | Total Catches (tons) | Catches from Italian trawlers (tons) |
|-----------------|----------------------|-------|----------------------|--------------------------------------|
| Status quo      | 3085                 | 1.377 | 3830                 | 3079                                 |
| Fmsy transition | 4597                 | 1.071 | 4439                 | 3689                                 |
| F weak          | 4505                 | 1.089 | 4424                 | 3674                                 |
| Annual 3%       | 3552                 | 1.280 | 4101                 | 3351                                 |
| Annual 5%       | 3854                 | 1.219 | 4237                 | 3487                                 |

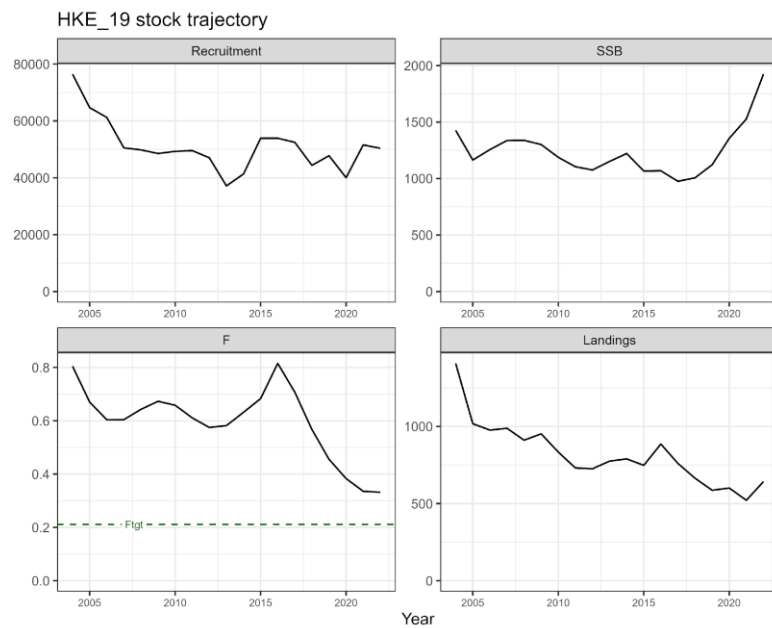
# Ionian Sea

Weak stock: HKE\_19

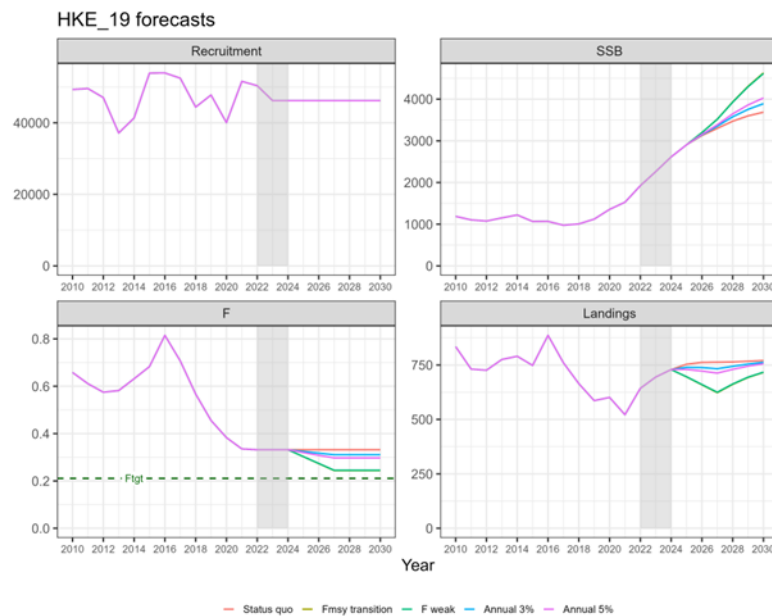
## Fishing effort displacement 2018-2020



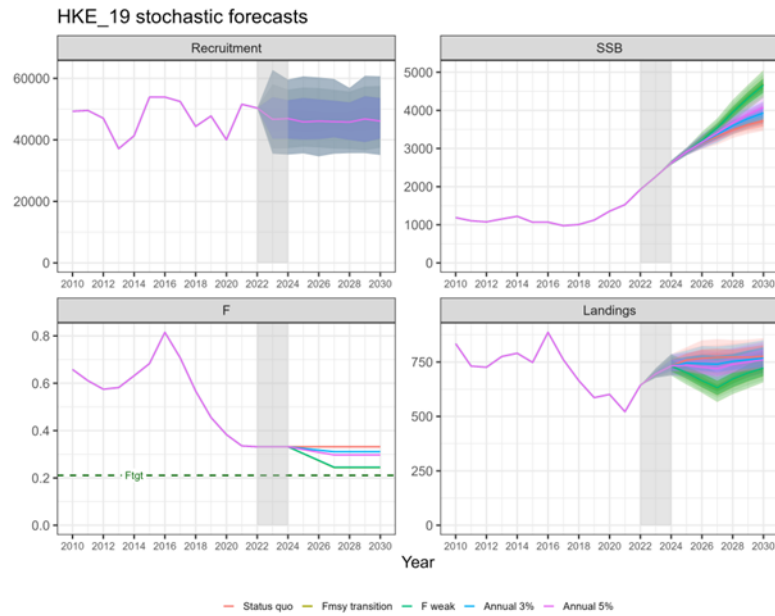
## HKE\_19



*HKE\_19 Stock trajectory from most recent stock assessment*



*HKE\_19 Deterministic forecast*

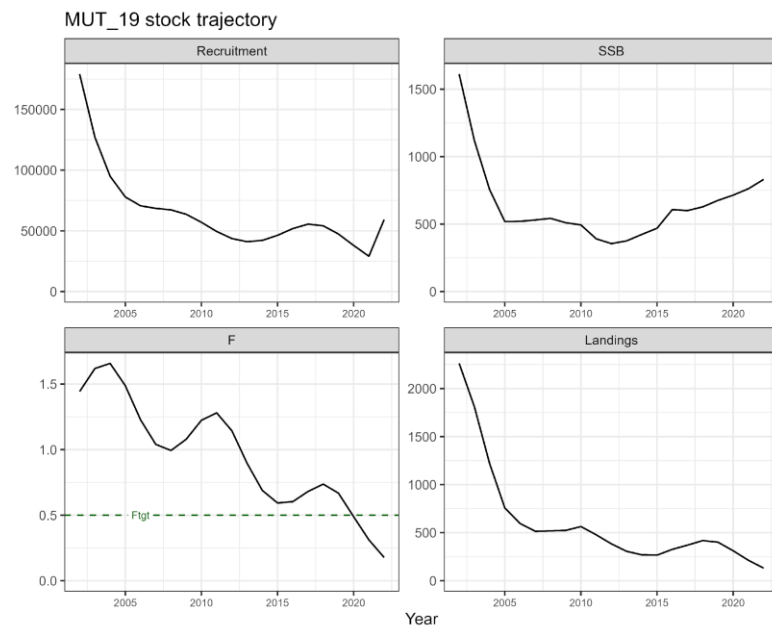


## HKE\_19 Stochastic forecast

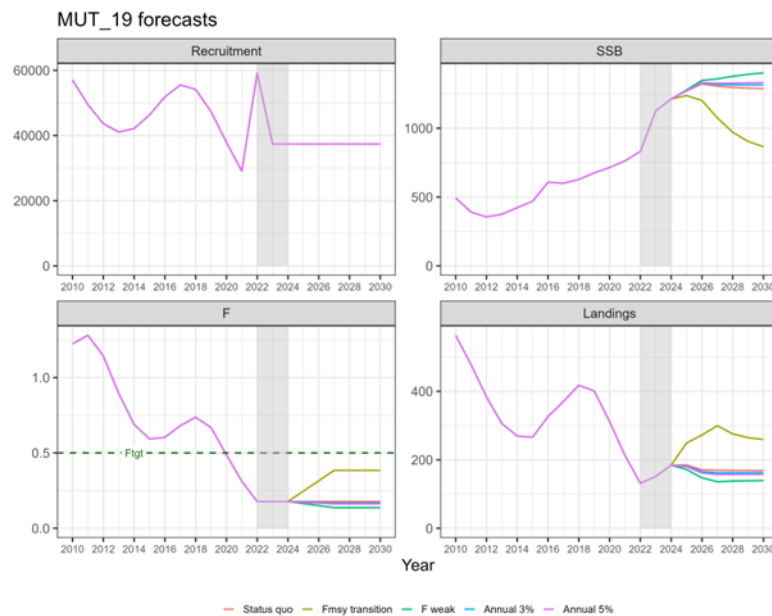
### Forecast results by scenario in 2030

| Scenario        | SSB (tons) | Fbar  | Total Catches (tons) | Catches from Italian trawlers (tons) |
|-----------------|------------|-------|----------------------|--------------------------------------|
| Status quo      | 3687       | 0.332 | 771                  | 560                                  |
| Fmsy transition | 4629       | 0.244 | 716                  | 505                                  |
| F weak          | 4617       | 0.245 | 717                  | 506                                  |
| Annual 3%       | 3891       | 0.311 | 762                  | 551                                  |
| Annual 5%       | 4028       | 0.297 | 756                  | 545                                  |

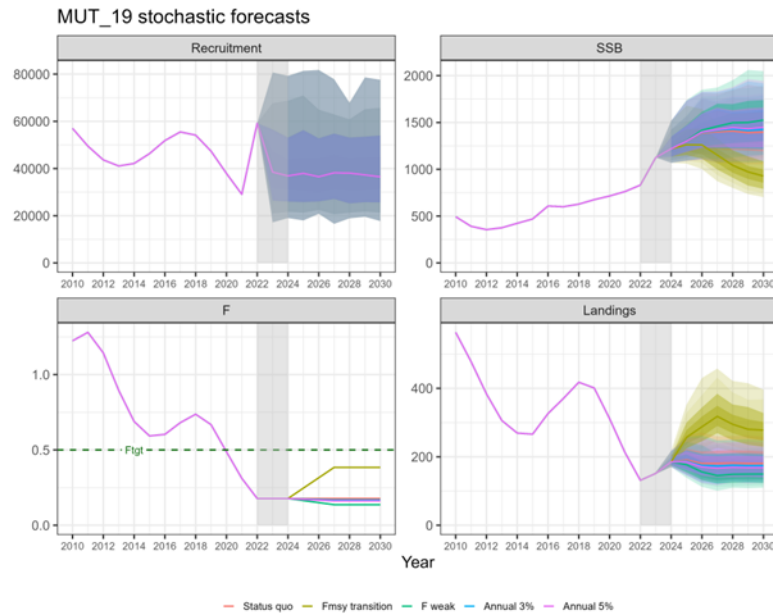
## MUT\_19



*MUT\_19 Stock trajectory from most recent stock assessment*



*MUT\_19 Deterministic forecast*

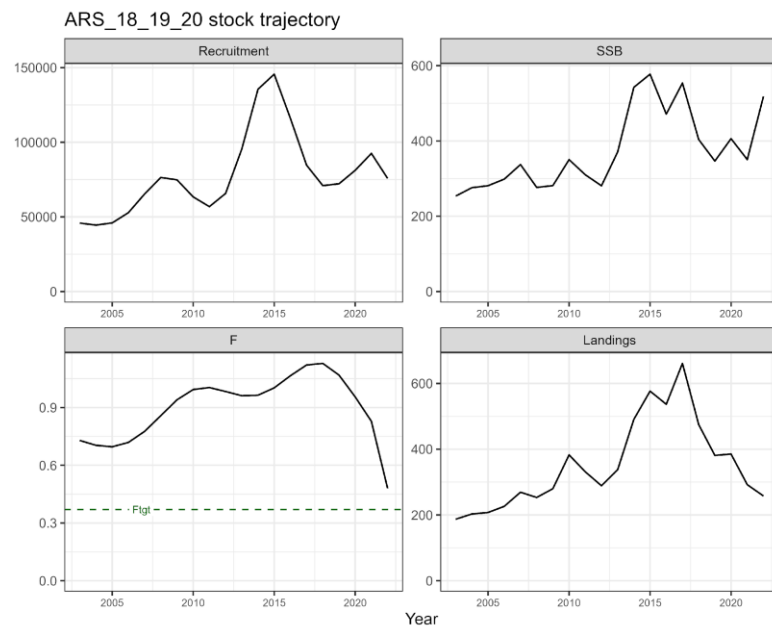


## MUT\_19 Stochastic forecast

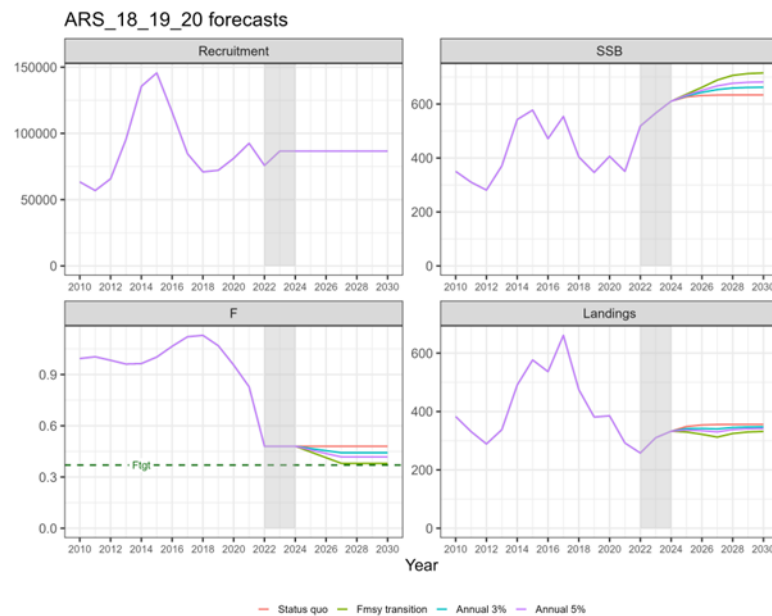
### Forecast results by scenario in 2030

| Scenario        | SSB (tons) | Fbar  | Total Catches (tons) | Catches from Italian trawlers (tons) |
|-----------------|------------|-------|----------------------|--------------------------------------|
| Status quo      | 1287       | 0.178 | 169                  | 108                                  |
| Fmsy transition | 865        | 0.384 | 259                  | 198                                  |
| F weak          | 1401       | 0.137 | 139                  | 78                                   |
| Annual 3%       | 1314       | 0.168 | 162                  | 101                                  |
| Annual 5%       | 1331       | 0.161 | 158                  | 97                                   |

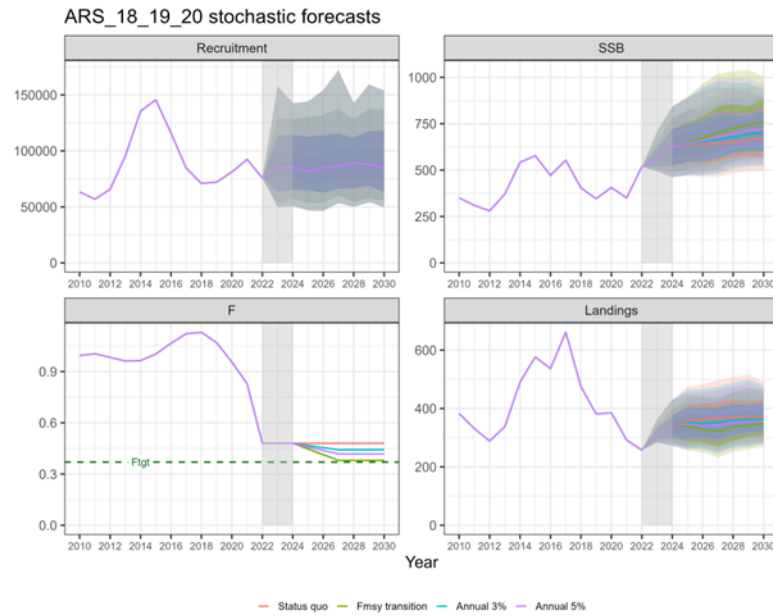
## ARS\_18\_19\_20



## ARS\_18\_19\_20 Stock trajectory from most recent stock assessment



## ARS\_18\_19\_20 Deterministic forecast



### *ARS\_18\_19\_20 Stochastic forecast*

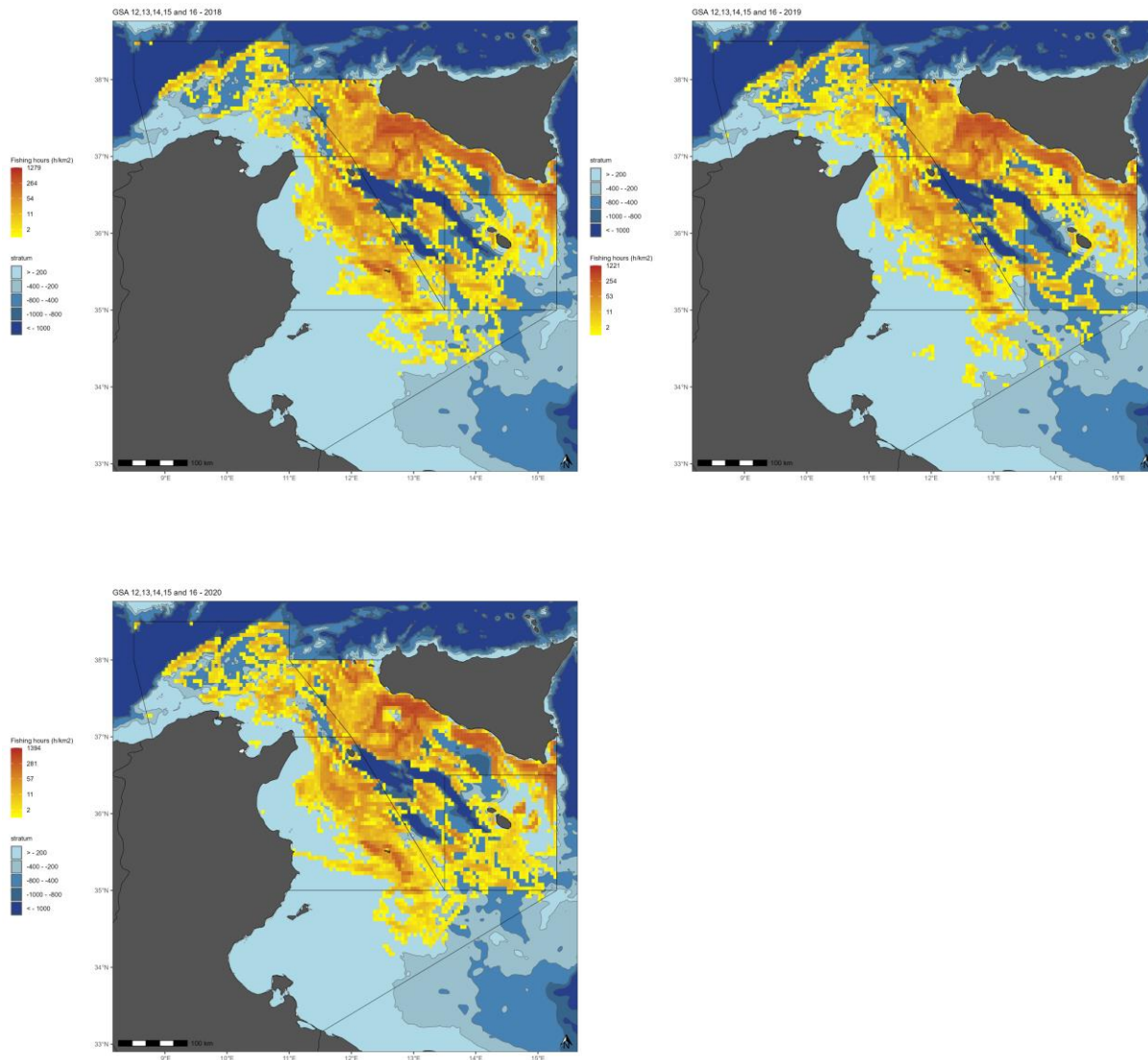
#### *Forecast results by scenario in 2030*

| Scenario        | SSB (tons) | Fbar  | Total Catches (tons) | Catches from Italian trawlers (tons) |
|-----------------|------------|-------|----------------------|--------------------------------------|
| Status quo      | 634        | 0.480 | 356                  | 324                                  |
| Fmsy transition | 715        | 0.380 | 332                  | 300                                  |
| Annual 3%       | 662        | 0.442 | 348                  | 316                                  |
| Annual 5%       | 682        | 0.418 | 342                  | 310                                  |

## Strait of Sicily

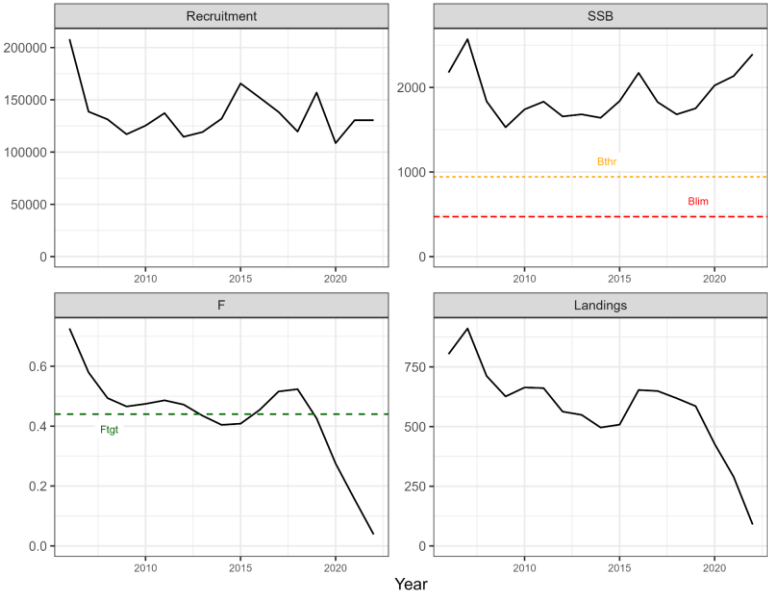
Weak stock: ARS 12\_13\_14\_15\_16\_21

### Fishing effort displacement 2018-2020

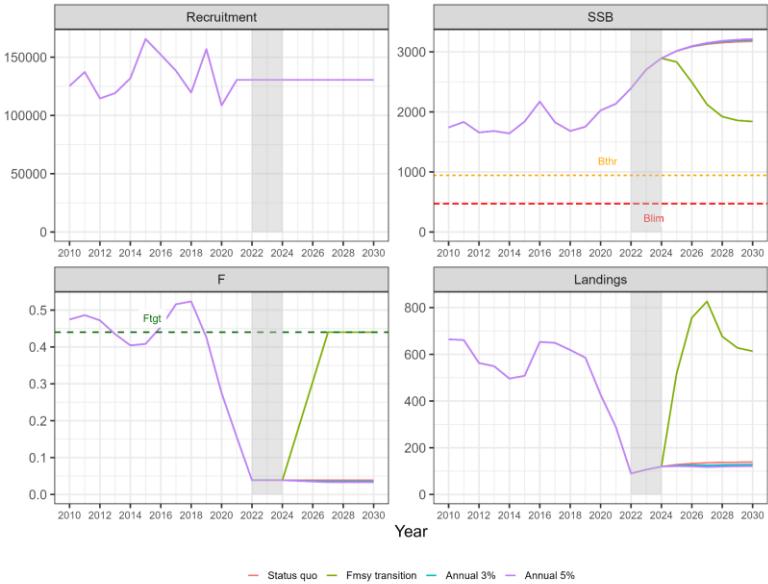


MUT\_16

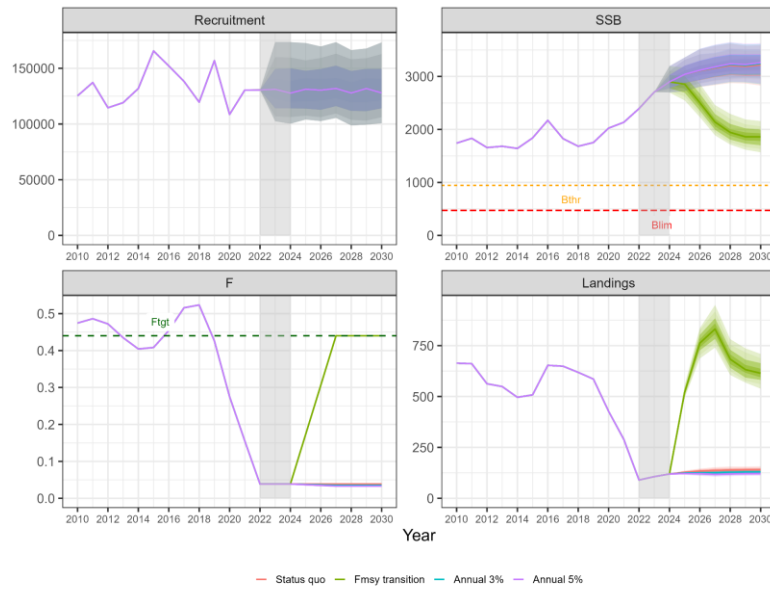
MUT\_16 stock trajectory



MUT\_16 forecasts



MUT\_16 stochastic forecasts

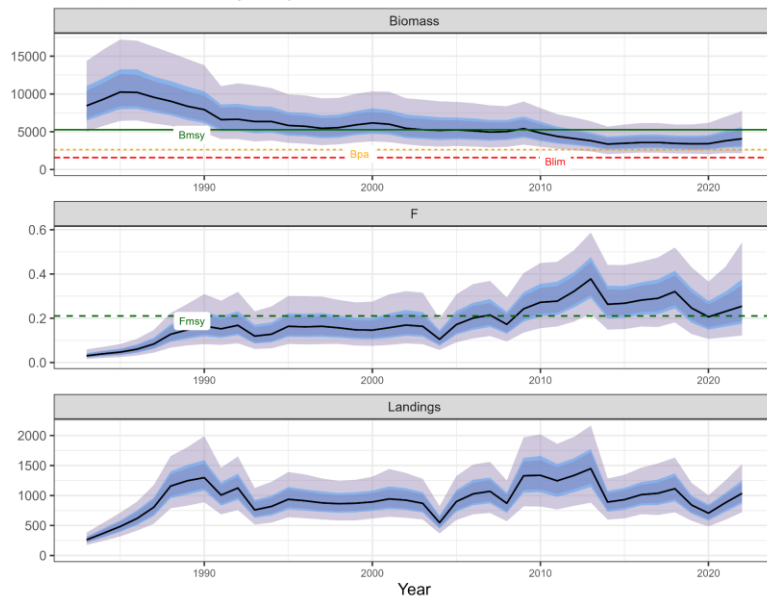


Forecast results by scenario in 2030

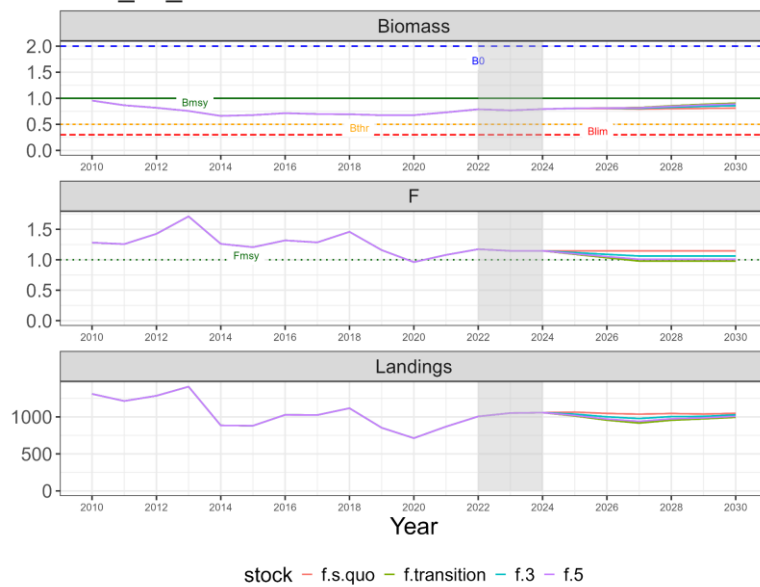
| Scenario        | SSB (tons) | Fbar  | Total Catches (tons) | Catches from Italian trawlers (tons) |
|-----------------|------------|-------|----------------------|--------------------------------------|
| Status quo      | 3176       | 0.039 | 139                  | 139                                  |
| Fmsy transition | 1840       | 0.440 | 613                  | 613                                  |
| Annual 3%       | 3199       | 0.035 | 128                  | 128                                  |
| Annual 5%       | 3215       | 0.033 | 121                  | 121                                  |

## ARS\_12\_13\_14\_15\_16\_21

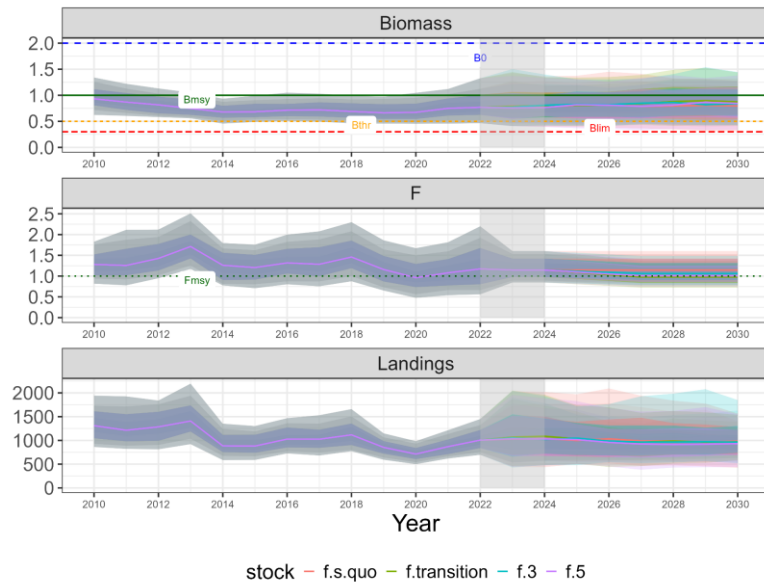
ARS\_12\_16 stock trajectory



ARS\_12\_16 forecasts



### ARS\_12\_16 stochastic forecasts

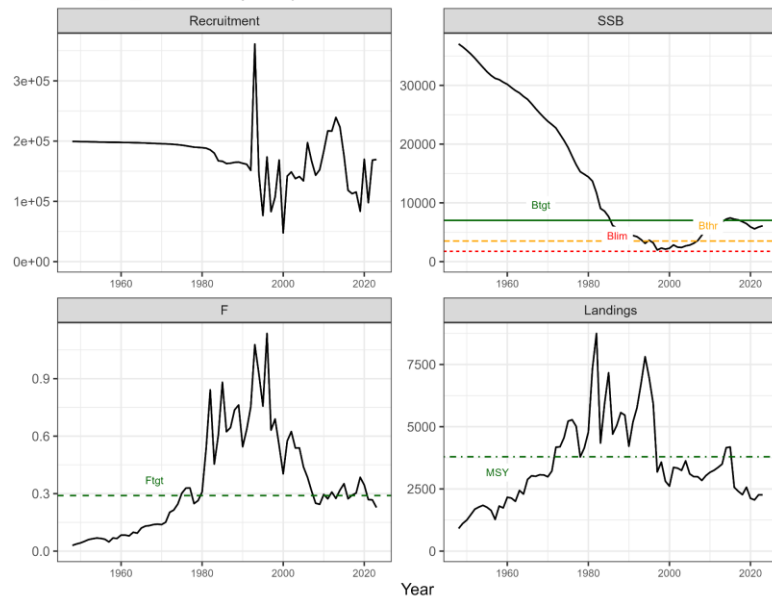


### Forecast results by scenario in 2030

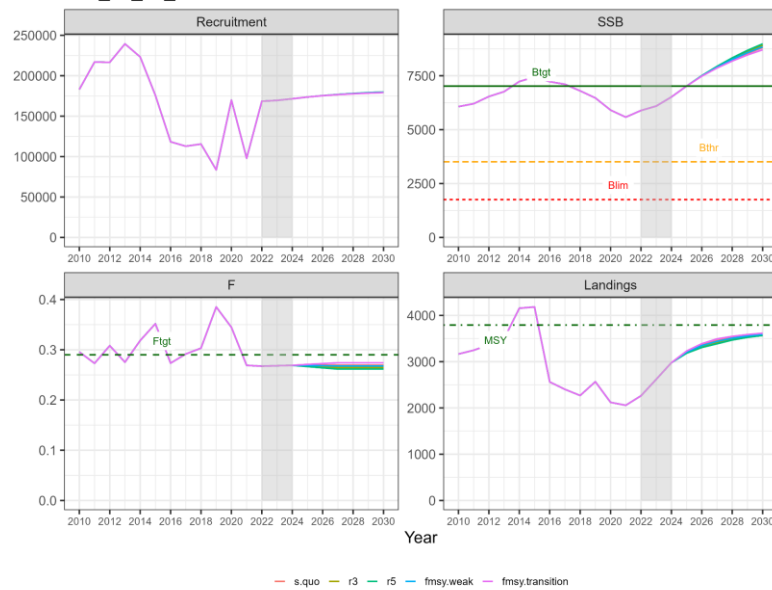
| Scenario            | SSB (tons) | Fbar   | Total Catches (tons) | Catches from Italian trawlers (tons) |
|---------------------|------------|--------|----------------------|--------------------------------------|
| <i>f.s.quo</i>      | 4117       | 1.204  | 1048                 | 886                                  |
| <i>f.transition</i> | 4576       | 0.978  | 994                  | 831                                  |
| <i>f.3</i>          | 4358       | 1.1158 | 1027                 | 865                                  |
| <i>f.5</i>          | 4500       | 1.059  | 1007                 | 845                                  |

## HKE\_12\_13\_14\_15\_16

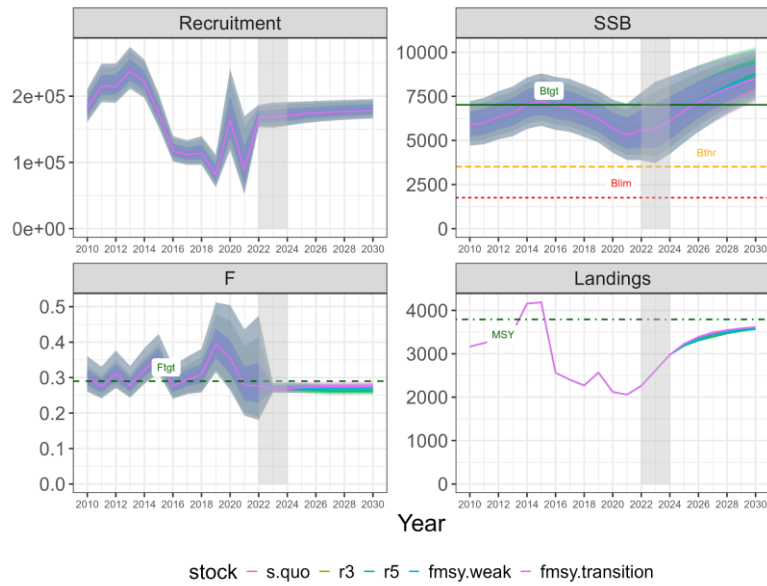
HKE\_12\_16 stock trajectory



Hke\_12\_16\_forecasts



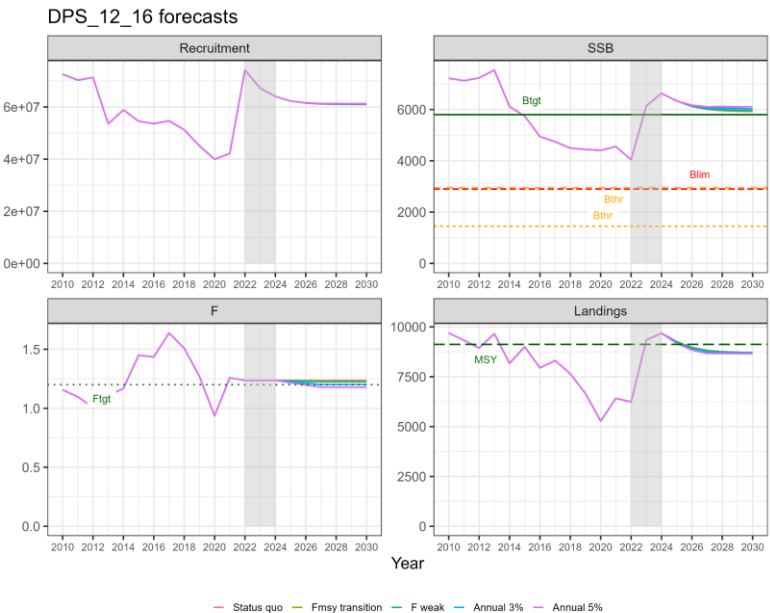
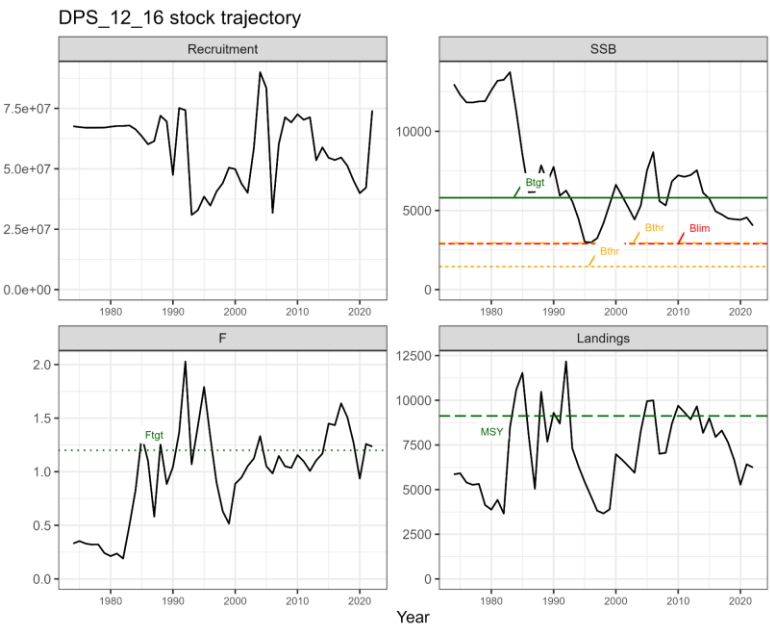
### HKE\_12\_16 stochastic forecasts

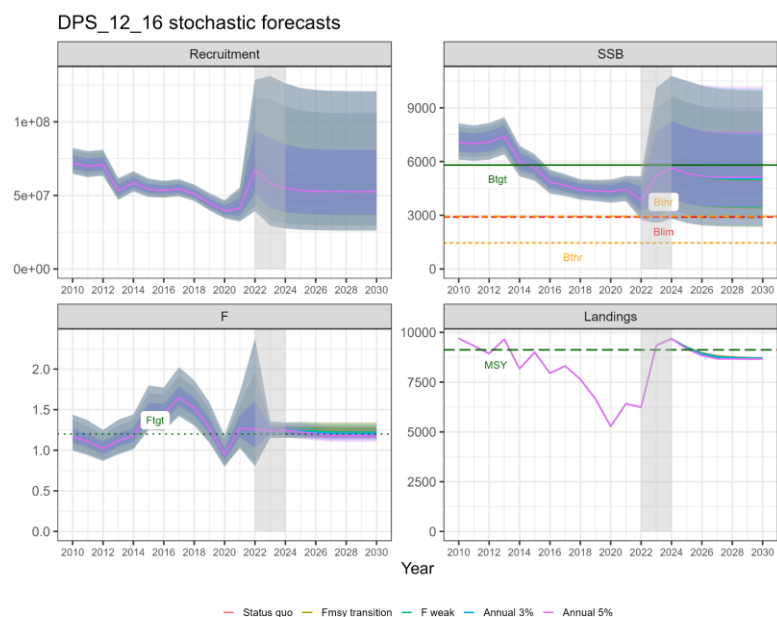


### Forecast results by scenario in 2030

| Scenario        | SSB (tons) | Fbar  | Total Catches (tons) | Catches from Italian trawlers (tons) |
|-----------------|------------|-------|----------------------|--------------------------------------|
| Status quo      | 8807       | 0.269 | 3598                 | 760                                  |
| Fmsy transition | 8707       | 0.274 | 3616                 | 816                                  |
| F weak          | 8842       | 0.268 | 3592                 | 740                                  |
| Annual 3%       | 8912       | 0.265 | 3579                 | 702                                  |
| Annual 5%       | 8979       | 0.262 | 3567                 | 664                                  |

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### Forecast results by scenario in 2030

| Scenario        | SSB (tons) | Fbar  | Total Catches (tons) | Catches from Italian trawlers (tons) |
|-----------------|------------|-------|----------------------|--------------------------------------|
| Status quo      | 5926       | 1.236 | 8720                 | 2829                                 |
| Fmsy transition | 5962       | 1.225 | 8707                 | 2770                                 |
| F weak          | 5964       | 1.224 | 8707                 | 2767                                 |
| Annual 3%       | 6037       | 1.201 | 8681                 | 2647                                 |
| Annual 5%       | 6111       | 1.178 | 8655                 | 2526                                 |

## References

- Coro, G., Tassetti, A. N., Armelloni, E. N., Pulcinella, J., Ferrà, C., Sprovieri, M., Trincardi, F., and Scarcella, G., 2022. COVID-19 lockdowns reveal the resilience of Adriatic Sea fisheries to forced fishing effort reduction. *Sci Rep* 12, 1052, <https://doi.org/10.1038/s41598-022-05142-w>, 2022.
- Galdelli, A., Armelloni, E.N., Ferra, C., Pulcinella, J., Scarcella, G. and Tassetti, A.N. 2021 . R4AIS: an R workflow to process AIS data for fishery. Zenodo [code], <https://doi.org/10.5281/zenodo.4761890>, 482 2021.
- GFCM-2023. Working Group on Stock Assessment of Demersal Species (WGSAD), FAO, November 2023. Report available: <https://www.fao.org/gfcm/technical-meetings/detail/en/c/1635049/>
- Pulcinella, J., Armelloni, E.N., Ferrà, C., Scarcella, G. and Tassetti, A.N., 2023. Deepwater red shrimp fishery in the eastern–central Mediterranean Sea: AIS-observed monthly fishing effort and frequency over 4 years. *Earth System Science Data*, 15(2), pp.809-820.
- STECF. 2023. “Scientific, Technical and Economic Committee for Fisheries (STECF) - Stock Assessments in the Western Mediterranean Sea (STECF 23-09) Mannini, a., Ligas, a. And Pierucci, a. Editor(s).” Luxembourg. [10.2760/995295](https://doi.org/10.2760/995295), [JRC135661](https://doi.org/10.2760/995295).