44th ANNUAL MEETING OF NAFO - SEPTEMBER 2022

COMPILATION of SC Response to Feedback Questions Regarding its Scientific Advice

From European Union [COM WP 22-35]	1. Regarding 3M Cod assessment, EU would like SC to inform which F would correspond with a 50% probability of SSB_{2025} being greater than SSB_{2022} (according to table 2 of the provided assessment).
Scientific Council responded [COM WP 22-38 Rev.]	Two projections based on Fishing Mortality have been performed to get $P(SSB_{25}>SSB_{22})=50\%$ and $P(SSB_{25}>SSB_{22})=75\%$. Results for these two projections are in Tables 1 and 2 as in the advisory sheet of the 3M cod. Table 1 includes the results for the two new projections, while Table 2 shows the risk results for the projections from the advisory sheet together with the two new ones, sorted by the $P(SSB_{25}>SSB_{22})$. New projections in Table 2 are bolded. The F that gives a $P(SSB_{25}>SSB_{22})=50\%$ is $0.595*F_{lim}=0.099$. **The F that gives a $P(SSB_{25}>SSB_{22})=75\%$ is $0.046*F_{lim}=0.076$**. **Table 1.** Results of the projections of 3M cod with $F_{bar} = 0.595*F_{lim} = 0.099$ (giving a $P(SSB_{25}>SSB_{22})=50\%$) and $F_{bar} = 0.46F_{lim} = 0.089$ ($P(SSB_{25}>SSB_{22})=75\%$).

	B		SSB		Yield
	Median and 80% CI				
F_{bar} = 0.595*Flim (median = 0.099)					
2022	50511	(45475 - 56297)	25994	(23085 - 28992)	4000
2023	48942	(43410 - 55808)	22651	(19983 - 25601)	6364
2024	46841	(40525 - 54987)	23252	(20012 - 26635)	7507
2025	42058	(34385 - 50956)	26175	(21473 - 31560)	
F_{bar} = 0.46*Flim (median = 0.089)					
2022	50511	(45475 - 56297)	25994	(23085 - 28992)	4000
2023	48942	(43410 - 55808)	22651	(19983 - 25601)	5050
2024	48219	(41880 - 56341)	24447	(21252 - 27888)	6207
2025	44583	(36905 - 53473)	28311	(23650 - 33758)	

Table 2. Risk of the projections presented in June together risk of the projections with F_{bar} = 0.595*F_{lim} = 0.099 (giving a P(SSB_{25}>SSB_{22})=50%) and F_{bar} = 0.46F_{lim} = 0.089 (P(SSB_{25}>SSB_{22})=75%). The results are sorted by P(SSB_{25}>SSB_{22}). The new projections are bolded.

	Yield			P(SSB < B_{lim})				P(F_{bar} > F_{lim})		
	2022	2023	2024	2022	2023	2024	2025	2022	2023	2024
F=0	4000	0	0	<1%	<1%	<1%	<1%	<1%	<1%	<1%
F_{2021} = 0.022	4000	3425	4429	<1%	<1%	<1%	<1%	<1%	<1%	<1%
C = 4000t	4000	4000	4000	<1%	<1%	<1%	<1%	<1%	<1%	<1%
C = 5000t	4000	5000	5000	<1%	<1%	<1%	<1%	<1%	<1%	<1%
0.46*F_{lim} = 0.076	**4000**	**5050**	**6207**	**<1%**	**<1%**	**<1%**	**<1%**	**<1%**	**<1%**	**<1%**
1/2F_{lim} = 0.083	4000	5446	6610	<1%	<1%	<1%	<1%	<1%	<1%	<1%
F_{sq} = 0.089	4000	5791	6987	<1%	<1%	<1%	<1%	<1%	<1%	<1%
0.595*F_{lim} = 0.099	**4000**	**6364**	**7507**	**<1%**	**<1%**	**<1%**	**<1%**	**<1%**	**<1%**	**<1%**
2/3F_{lim} = 0.111	4000	7032	8128	<1%	<1%	1%	1%	<1%	<1%	<1%
3/4F_{lim} = 0.125	4000	7787	8790	<1%	<1%	1%	1%	<1%	<1%	3%
F_{lim} = 0.166	4000	9915	10431	<1%	<1%	3%	6%	<1%	50%	50%

From European Union [COM WP 22-35]

2. EU would like to seek additional clarifications to understand the apparent difference in the approach given to managing the risks associated to the projections of Cod 3M and Witch flounder 3NO. For 3M cod, scenarios with Fbar2024 > Flim achieving 3% (3/4 Flim) are not recommended because the probability of having SSB25>SSB22 is not very high (27%). For Witch flounder 3NO, SC recommends F associated to 19% risks of F2024>Flim knowing that recruitment was not determined. Furthermore, the recommendation for Witch flounder 3NO allows for scenarios where F approaches of up to 2/3 Fmsy although that would entail a probability of up to 9% of B being below Blim. In the case of Cod 3M the recommended scenario entails a risk of SSB < Blim of up to 1%.

Scientific Council responded [COM WP 22-42]

Advice is not based entirely on risk tables. The key difference between these stock assessments is that in the case of 3M Cod, the predicted decline in total biomass is under all scenarios except for F=0, as well as poor recruitment in recent years. This prompted the additional consideration of the trends in total biomass to formulate the advice, whereas for 3NO witch flounder total biomass was predicted to increase under all scenarios. Note that these two stocks are assessed with different models and available data sources.

SC consistently applies the NAFO precautionary framework which effectively includes conducting F projections up to F_{lim}, and considers an acceptable exploitation scenario to be those that have a very low (less than 10%) chance of being below B_{lim} and a low chance (less than 20%) of F>F_{lim}. Therefore, the advice for both stocks is consistent under those metrics.

From Russian Federation [COM WP 22-36]

Regarding response by SC to the Commission's request 5.b

The TCI (Total Catch Index) is proposed by the Scientific Council as a supplementary control measure in addition to the existing TAC and quota system. Having reviewed the proposal, the Russian Federation has several questions:

	1. TCI approach implies the aggregation of fish stocks into the following trophic guilds: benthivores, planktivores, piscivores, etc. Can the SC provide a clarification on the distribution of stocks according to that approach, i.e., which stock (as outlined in the quota table) goes to which guild? 2. The SC is requested to clarify if there are separate TCI values for different guilds within the same ecosystem. 3. The TACs within an ecosystem are supposed to be reduced to prevent the exceeding of 2xTCI if their sum exceeds the 2xTCI when compared. Can the SC give an example of such comparison for a known ecosystem and stocks inhabiting it? 4. The SC is requested to give an explanation on a situation when the sum of TACs for several stocks within an ecosystem exceeds the 2xTCI for that ecosystem. Are there any principles for selecting a stock for which TAC should be reduced to prevent the 2xTCI exceeding? 5. Some stocks (e.g., 3LMNO Greenland halibut) are distributed over a large area encompassing several ecosystems. The SC is requested to explain if there are any principles for assigning the TACs of such stocks, in whole or in part, to different ecosystems to compare the TACs with the ecosystems' 2xTCI values?
Scientific Council responded: [COM WP 22-41]	The TCI-framework and related 2TCI ecosystem reference point are intended to implement the Tier 1 component of the Roadmap, and as such, complement existing management measures by providing information relevant to ecosystem overfishing. 1. Mapping stocks to functional guilds is dependent on the trophic level at which production takes place. In most cases this mapping directly assigns species to functional guilds, but for some commercial species (i.e. those that contribute the most to the catches), the consideration of their life history and general diet composition has allowed splitting their production into different guilds. With this in mind, NAFO managed species within currently delineated Ecosystem Production Units (EPUs) are mapped to functional guilds as follow:

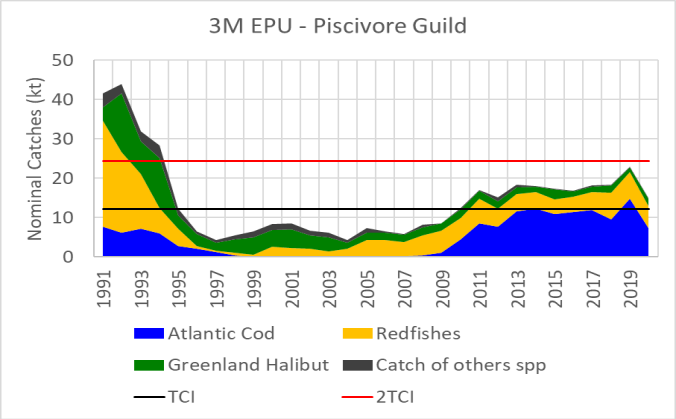
Species	Functional guild
Atlantic cod	Planktivore (small fish) and Piscivore (large fish)
Redfish	Planktivore (small fish) and Piscivore (large fish)
Greenland halibut	Piscivore
White hake	Piscivore
American plaice	Benthivore
Witch flounder	Benthivore
Thorny Skate	Benthivore

Shrimp	Benthivore
Capelin	Planktivore
Squid	Planktivore

2. Yes. There is a TCI value per functional guild within an EPU.

3. The implementation of the TCI framework and 2TCI ecosystem reference point provides information to the Commission regarding how aggregated catches relate to ecosystem productivity and the risk of ecosystem overfishing, but the proposed framework does not prescribe any specific action in the case that catches are approaching or exceeding 2TCI. How this information is used in the process of setting TACs is a matter for the Commission to consider as part of its discussions.

   Catches exceeding 2TCI are a rare occurrence in recent times, but in occasions, cumulative TACs could have allowed catches to exceed 2TCI if the TACs had been fully taken. One example of this situation was used during the August 2022 WGEAFFM Workshop to explore how the TCI framework and 2TCI reference points could be used in practice. This example corresponds to the piscivore guild in the Flemish Cap (3M) EPU in 2019. The following figure shows the piscivore guild catches since 1991. If all TACs had been fully taken, catches would have exceeded 2TCI in 2019.



4. The proposed framework does not prescribe any specific action in the case that catches are approaching or exceeding 2TCI. How this information is used in the process of setting TACs is a matter for the Commission to consider as part of its discussions.

5. For stocks like Greenland halibut which distribute over more than one EPU the TAC can be partitioned among EPUs, for instance based on the proportion of catches actually taken from each EPU, but this will be assessed on a case-by-case basis.

Reference links:

Koen-Alonso et al., Review and Assessment of the Ecosystem Production Potential (EPP) model structure, sensitivity, and its use for fisheries advice in NAFO. NAFO SCR Doc. 22/002 .

<table>
<tr><td></td><td>Koen-Alonso. Supporting material for the independent scientific review of the estimation of fisheries production potential and total catch indices, and their adequacy for their proposed used within the NAFO Roadmap. NAFO SCR Doc. 22/003.

Scientific Council response to Commission Request 5: Continue work on the sustainability of catches aspect of the Ecosystem Roadmap. NAFO SCS Doc. 22/18.</td></tr>
<tr><td>From the USA [COM WP 22-37]</td><td>In order to better understand how to support the growth of this stock over the long term, noting the projected total decline of total biomass under all fishing scenarios, what catch level in 2023 would result in a 75-percent probability of an increase in the spawning stock biomass for 3M cod by 2025?</td></tr>
<tr><td>Scientific Council responded [COM WP 22-38 Rev.]</td><td>Two projections based on Fishing Mortality have been performed to get P(SSB_{25}>SSB_{22})=50% and P(SSB_{25}>SSB_{22})=75%. Results for these two projections are in Tables 1 and 2 as in the advisory sheet of the 3M cod. Table 1 includes the results for the two new projections, while Table 2 shows the risk results for the projections from the advisory sheet together with the two new ones, sorted by the P(SSB_{25}>SSB_{22}). New projections in Table 2 are bolded.

The F that gives a P(SSB_{25}>SSB_{22})=50% is 0.595*F_{lim}=0.099. The F that gives a P(SSB_{25}>SSB_{22})=75% is 0.046*F_{lim}=0.076.

Table 1. Results of the projections of 3M cod with F_{bar} = 0.595*F_{lim} = 0.099 (giving a P(SSB_{25}>SSB_{22})=50%) and F_{bar} = 0.46F_{lim} = 0.089 (P(SSB_{25}>SSB_{22})=75%).
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	Yield			P(SSB < B_{lim})				P(F_{bar} > F_{lim})			
	2022	2023	2024	2022	2023	2024	2025	2022	2023	2024	P(SSB_{25} >S
F=0	4000	0	0	<1%	<1%	<1%	<1%	<1%	<1%	<1%	100%
F_{2021} = 0.022	4000	3425	4429	<1%	<1%	<1%	<1%	<1%	<1%	<1%	95%
C = 4000t	4000	4000	4000	<1%	<1%	<1%	<1%	<1%	<1%	<1%	94%
C = 5000t	4000	5000	5000	<1%	<1%	<1%	<1%	<1%	<1%	<1%	86%
0.46*F_{lim} = 0.076	**4000**	**5050**	**6207**	**<1%**	**<1%**	**<1%**	**<1%**	**<1%**	**<1%**	**<1%**	**75%**
1/2F_{lim} = 0.083	4000	5446	6610	<1%	<1%	<1%	<1%	<1%	<1%	<1%	67%
F_{sq} = 0.089	4000	5791	6987	<1%	<1%	<1%	<1%	<1%	<1%	<1%	60%
0.595*F_{lim} = 0.099	**4000**	**6364**	**7507**	**<1%**	**<1%**	**<1%**	**<1%**	**<1%**	**<1%**	**<1%**	**50%**
2/3F_{lim} = 0.111	4000	7032	8128	<1%	<1%	1%	1%	<1%	<1%	<1%	39%
3/4F_{lim} = 0.125	4000	7787	8790	<1%	<1%	1%	1%	<1%	<1%	3%	27%
F_{lim} = 0.166	4000	9915	10431	<1%	<1%	3%	6%	<1%	50%	50%	9%

From Denmark (in respect of the Faroe Islands and Greenland) [COM WP 22-39]

DFG supports the Catch and Effort Limitation outline in NAFO CEM Article 5.5(j) stating that:

> 5. Each Contracting Party shall:
>
> (j) close its directed fishery for cod in Division 3M between 00:00 UTC 1 January 2022 and 24:00 UTC 31 March 2022. During this period, all Contracting Parties shall ensure that its vessels limit the catches retained on board and in any one haul of this stock in line with Article 6.3(a) and observe the move-on provisions in Article 6.6(b).

DFG appreciates and supports this temporary protective measuring in Article 5.5(j) concerning Cod in Division 3M during its spawning season.

DFG would like the Scientific Council to provide guidance on the following:

- Is it scientifically advisable for the stock during the spawning season to reduce the protective measure in Article 5.5(j) from three months (00:00 UTC 1 January 2023 and 24:00 UTC 31 March 2023) to two months (00:00 UTC 1 February 2023 and 24:00 UTC 31 March 2023)?

- If it is not scientifically advisable to reduce the protective measuring in Article 5.5(j) from three months to two months, is it scientifically advisable to move the three-month protective measure so that its starts 00:00 UTC 1 February 2023 and 24:00 UTC 30 April 2023?

Scientific Council responded: [COM WP 22-47]

During its June 2020 meeting, SC studied the percentage of spawning female cod by month in Div. 3M for the 2010-2018 period (SCR Doc. 20-021, SCS Doc. 20-014Rev.), the results are presented in Table 1:

Table 1. Percentage of spawning female cod by month in Div. 3M for the 2010-2018.

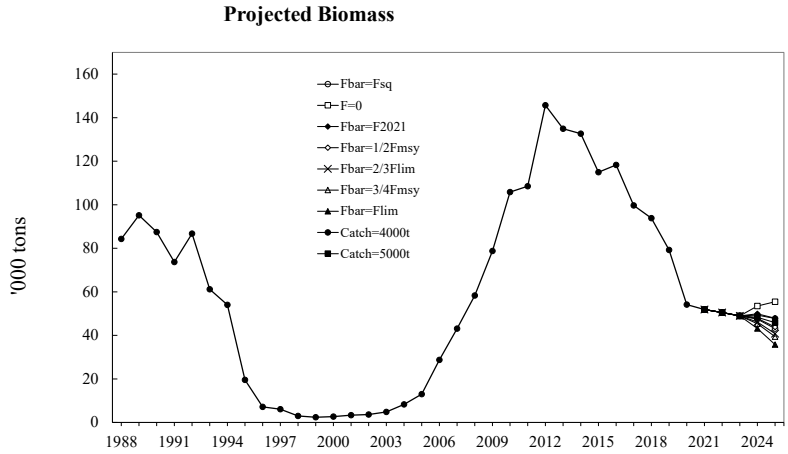
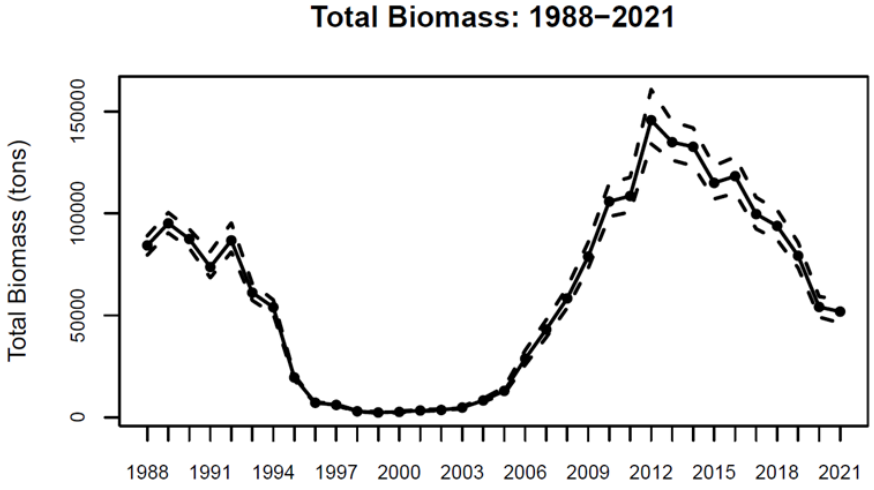
	<table><tr><th>Month</th><th>Spawning %</th><th>Not Spawning %</th><th>n</th></tr><tr><td>Jan</td><td>88.89</td><td>11.11</td><td>90</td></tr><tr><td>Feb</td><td>72.73</td><td>27.27</td><td>33</td></tr><tr><td>Mar</td><td>60.12</td><td>39.88</td><td>1457</td></tr><tr><td>Apr</td><td>18.35</td><td>81.65</td><td>1695</td></tr><tr><td>May</td><td>1.80</td><td>98.20</td><td>557</td></tr><tr><td>Jun</td><td>0.11</td><td>99.89</td><td>950</td></tr><tr><td>Jul</td><td>8.14</td><td>91.86</td><td>921</td></tr><tr><td>Aug</td><td>0.27</td><td>99.73</td><td>728</td></tr><tr><td>Sep</td><td>0.40</td><td>99.60</td><td>506</td></tr><tr><td>Oct</td><td>0.78</td><td>99.22</td><td>257</td></tr></table> Spawning of 3M cod occurs between January and April, with the highest activity being in the first three months, and January being the month with highest percentage of spawning females (Table 1.). SC concludes that, in order to protect the spawning activity, it is not scientifically advisable to change the duration or timing of the spawning closure and that it should therefore be maintained for the entire first quarter of the year (from 1st January until 31st of March).
From Norway [COM WP 22-43]	The 3M shrimp stock is managed by fishing-days while Scientific Council provides advice in terms of catch ("TAC advice"). This creates ambiguity in using the scientific advice to inform management and promote efficient and sustainable utilization of this resource. SC advised that they do "*not consider that the management procedure initiated some 25 years ago constitutes effective means of managing the stock*" and that they recommend "*that the management of 3M shrimp be converted from the existing "effort regulation" to "catch regulation" in line with all other stocks in the NRA*" ((SCS 19-23, pp 4-5 and reiterated in the advice for shrimp in 3M for 2023). In the event of a reopening of the fishery, and the COM has not agreed on a new allocation scheme, the fishing activity will be resumed based on the current effort allocation key. Consequently, there will still be a need for advice in terms of fishing days. We therefore ask SC to reflect on: 1. the opportunities for converting "catch advice" into "fishing-day advice" e.g., by applying estimates of average catch rates (catch by fishing-day). As SC noted in SCS 19-23 such estimates may be uncertain for various reasons, nevertheless, in need of other means of providing advice in accordance with the management needs, this might still be the best we can do. 2. whether it would be feasible to include both metrics in future advice, i.e., Total Allowable Catch (TAC) and Total Allowable Fishing-days (TAF) – the latter maybe with some indication of the associated uncertainty or range as SC finds appropriate.

	3. whether such additional information could assist COM in their reiterated aim at ensuring a sustainable management of this stock.
Scientific Council responded: [COM WP 22-49]	**1.** SC reiterates the advice provided in SCS 19-23: over the period of this fishery the overall effort allowed has always been high and has not posed much constraint on fishing activity, and it is difficult to standardize "effort units" (e.g. fishing days) in terms of pressure on the stock due to creep in fishing efficiency and the diversity of the individual vessels participating in the fishery. This increases the uncertainty of advice given in fishing days. Therefore, SC recommended that the management of 3M shrimp be converted from the existing "effort regulation" to a "catch regulation" in line with all other stocks in the NRA. However, when the catch/days fishing (df, Table 1) from any year from 2000-2010 (effort data from STATLANT 21B) and 2020-2021 (From SC shrimp meeting 2022) is applied to the recommended TAC from 2019, the range of total days fished to be allocated ranges from 193 to 1448 total days (Table 2). This is much lower than the 2640 allocated in 2020 and 2021. **2.** Given the range in days fished arising from Table 2, it would be difficult to give advice on total allowable days. **Table 1.** Calculation of tonnes per fishing day based on catches and effort used in the years 2000 to 2021.

	NIPAG Catch (000s t)	Recommended TAC (000s mt)	Allocated Effort (days)	Effort Used (days)	tonnes /days fishing
2000	50	30		3200	15.6
2001	54	30		5445	9.9
2002	49	45		4237	11.6
2003	63	45		5243	12.0
2004	45	45		4042	11.1
2005	32	48		2155	14.8
2006	18	48	10555	1049	17.2
2007	21	48	10555	1335	15.7
2008	13	17-32	10555	1069	12.2
2009	5	18-27	10555	447	11.2
2010	2	ndf	5277	71	28.2
2020	0.079	5.448	2640	21	3.8
2021	6.042	5.448	2640	440	13.7

Table 2. Fishing effort that would have been advised for a TAC of 5448 tonnes using observed catch rates from table 1.

	tonnes/days fishing — **Days fishing for a recommended catch of 544 tonnes** 15.6 — 349 9.9 — 549 11.6 — 471 12.0 — 453 11.1 — 489 14.8 — 367 17.2 — 317 15.7 — 346 12.2 — 448 11.2 — 487 28.2 — 193 3.8 — 1448 13.7 — 397 **3.** Scientific Council reiterates that management by TAC is the most appropriate way to manage the fishery. Nevertheless, setting the allocated days to those close to the values shown in the last column of table 2 could assist in managing this fishery better than it is currently. SC notes that these values would be a factor of 10 lower than the currently allocated days.
From Canada [COM WP 22-44]	Given the different interpretation by Contracting Parties of the total stock biomass trajectory for 3M cod, can the Scientific Council confirm that the total biomass is projected to decline under all fishing scenarios? Can the Scientific Council confirm that the total biomass has decreased in recent years? Can the Science Council advise the range of fishing scenario where total stock biomass is projected to increase?

Scientific Council responded: [COM WP 22-50]	The biomass for 3M cod is projected to decline in the last year projected (2025) under all the fishing scenarios (other than F=0) that were performed during the June SC meeting (Figure 1):  **Figure 1.** Projections for Total Biomass with different scenarios (STACTFIS report for 3M cod). The results of the assessment performed for 3M cod results in the biomass decreasing starting in 2013:  **Figure 2.** Estimated trends in total biomass. The solid line is the posterior median and the dashed lines show the limits of 80% posterior credible intervals (SCR 22/25). Projecting F values show that the highest F value for which the Total Biomass of cod is projected to increase in 2025 is F_{bar}=0.03 (Table 1). It has to be noted that the uncertainty in the projected years is higher than in the assessment years, and so the confidence interval for the Total Biomass for 2025 is higher than the one for 2022.

SC notes that projections of total biomass are more highly dependent on assumptions of recruitment and year classes that are poorly estimated than would be the case for SSB projections.

Table 1. Results of the projections of 3M cod with several F_{bar}.

	B		SSB		Yield
	Median and 80% CI				
$F_{bar} = F_{sq}$ (median = 0.089)					
2022	50511	(45475 - 56297)	25994	(23085 - 28992)	4000
2023	48942	(43410 - 55808)	22651	(19983 - 25601)	5791
2024	47441	(41115 - 55572)	23797	(20536 - 27170)	6987
2025	43101	(35439 - 52003)	27046	(22345 - 32507)	
$F_{bar} = 0$					
2022	50511	(45475 - 56297)	25994	(23085 - 28992)	4000
2023	48942	(43410 - 55808)	22651	(19983 - 25601)	0
2024	53489	(47131 - 61613)	29062	(25841 - 32474)	0
2025	55443	(47659 - 64531)	37876	(33038 - 43336)	
$F_{bar} = 0.033$ (median)					
2022	50511	(45475 - 56297)	25994	(23085 - 28992)	4000
2023	48942	(43410 - 55808)	22651	(19983 - 25601)	2274
2024	51101	(44757 - 59241)	27004	(23750 - 30334)	3044
2025	50329	(42598 - 59287)	33360	(28532 - 38763)	
$F_{bar} = 0.030$ (median)					
2022	50511	(45475 - 56297)	25994	(23085 - 28992)	4000
2023	48942	(43410 - 55808)	22651	(19983 - 25601)	2105
2024	51280	(44938 - 59422)	27112	(23908 - 30578)	2832
2025	50695	(42952 - 59678)	33622	(28843 - 39139)	