Multispecies modelling: estimation of reference points and assessment of joint HCRs that take into consideration ecological interactions

CAPAM workshop 2019

EU SC05 project:
"Multispecies Fisheries Assessment for NAFO"

Alfonso Pérez-Rodríguez
Institute of Marine Research
Department of Demersal Fish
Bergen, Norway

European Maritime and Fisheries Fund
Framework Programme UE EMFF/2016/008

European Commission

WAGENINGEN UNIVERSITY & RESEARCH

HAVFORSKNINGSINSTITUTTET INSTITUTE OF MARINE RESEARCH

European Commission Joint Research Centre

INSTITUTO ESPAÑOL DE OCEANOGRAFÍA

Cefas

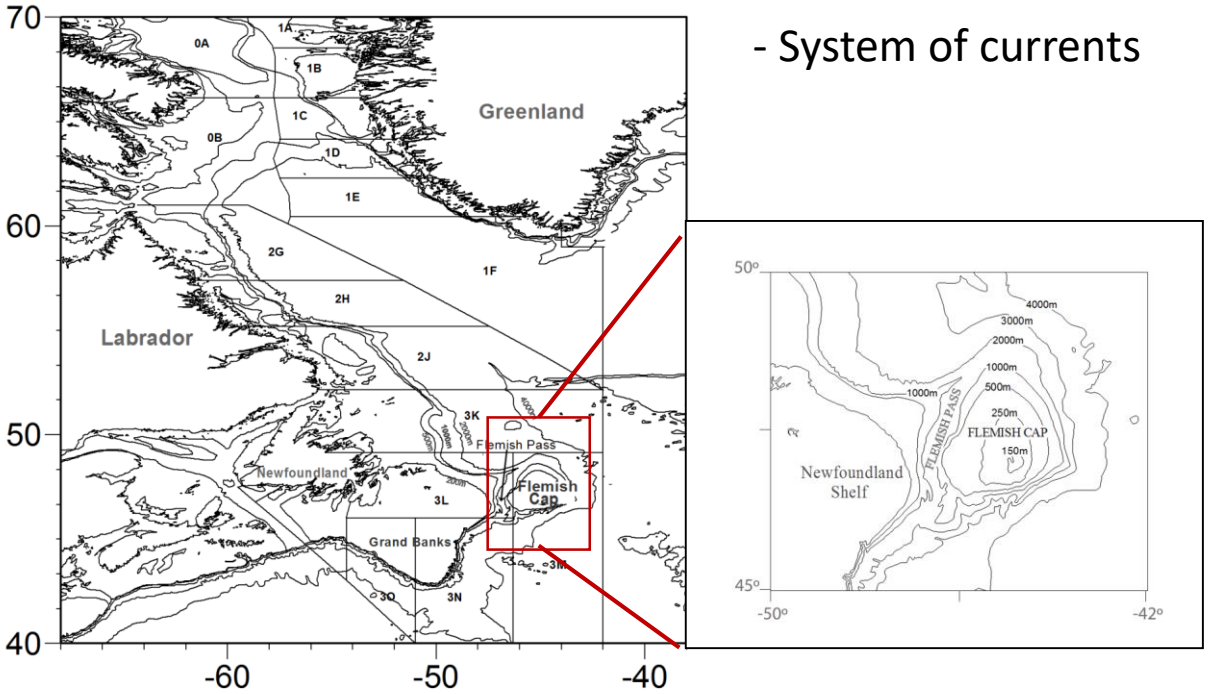
azti tecnalia

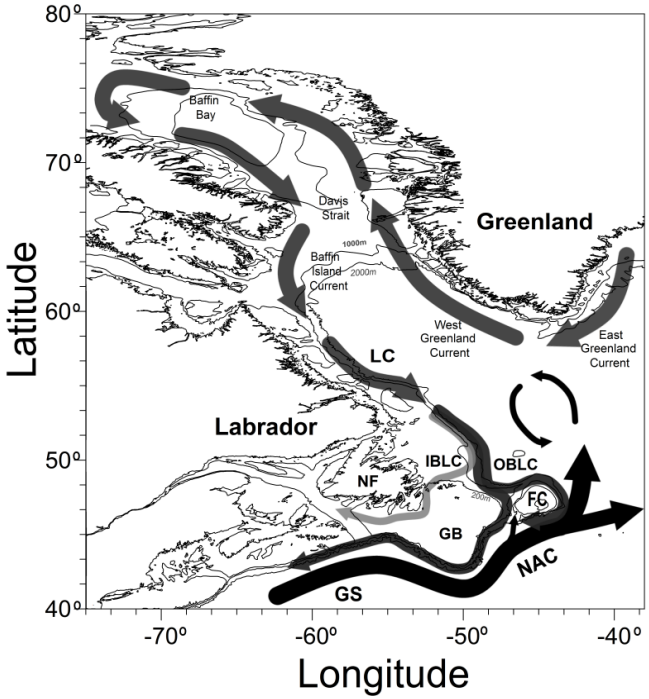
ipma instituto português do mar e da atmosfera

MRAG

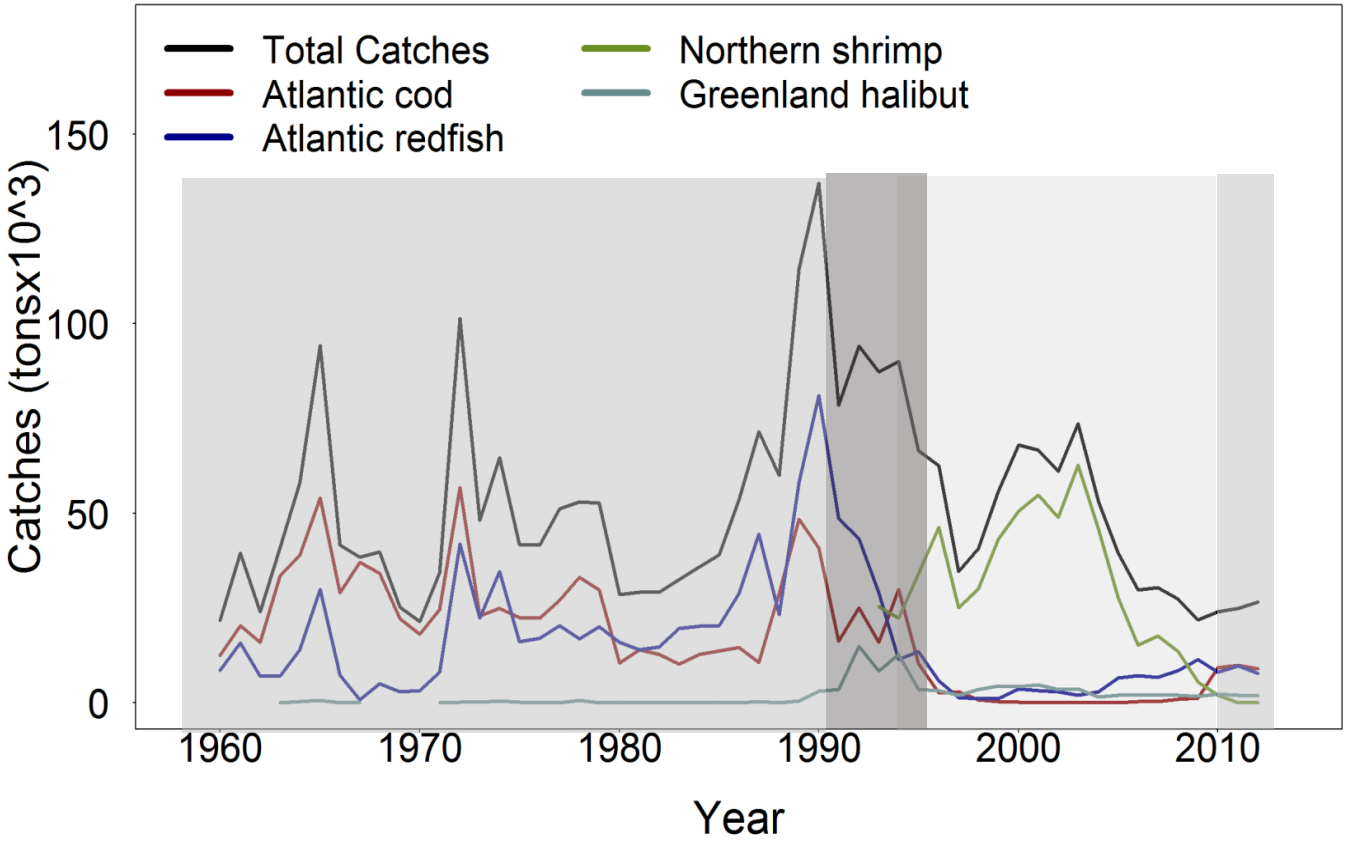
Flemish Cap, NAFO área 3M
Location and isolation

- NAFO area 3M
- Deep water mountain
- Flemish Pass
- System of currents





Fishing history



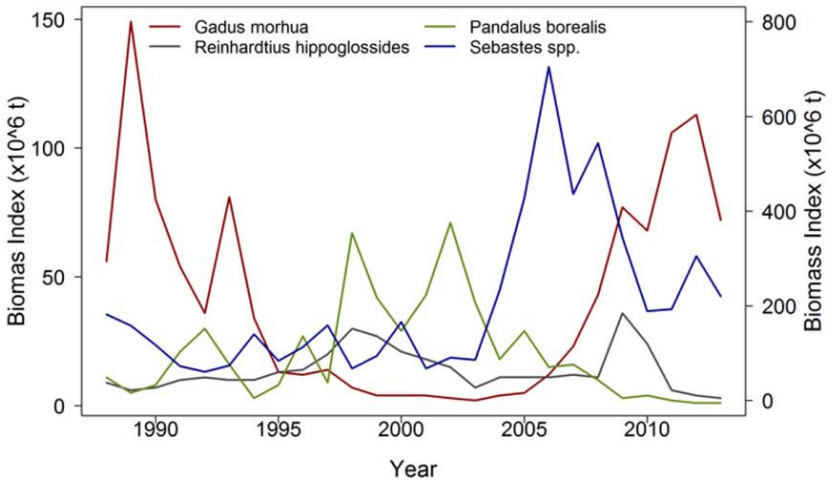
-1960-early 1990s: cod and redfish

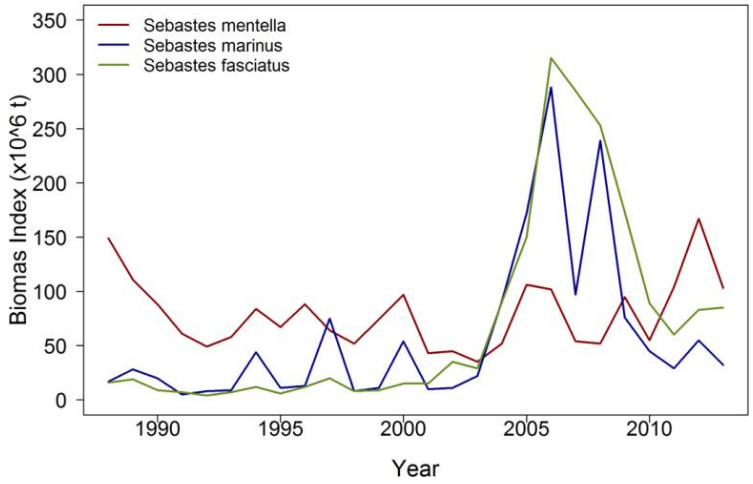
- Mid 1990s: transition.

- Late 1990s-2010: shrimp and Greenland halibut

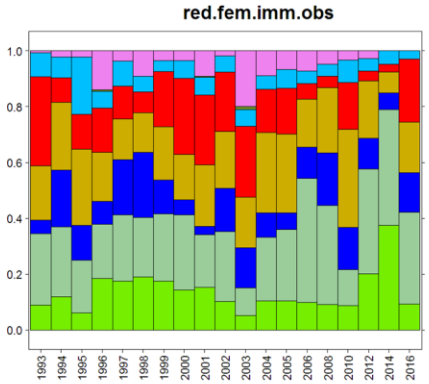
- 2010-2018: cod and redfish

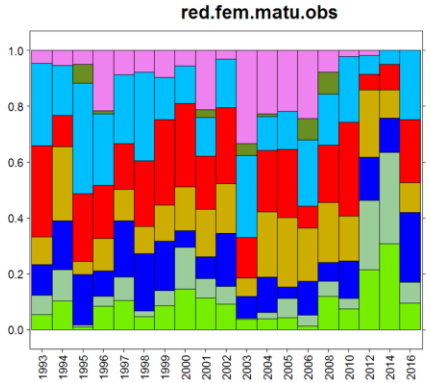
Survey index
Cod, redfish and shrimp

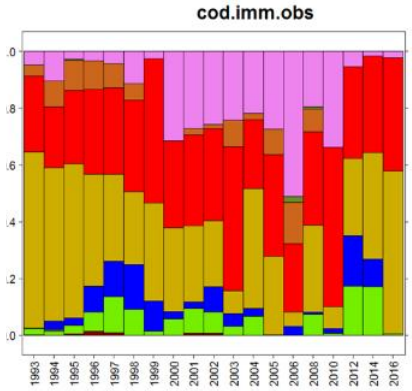


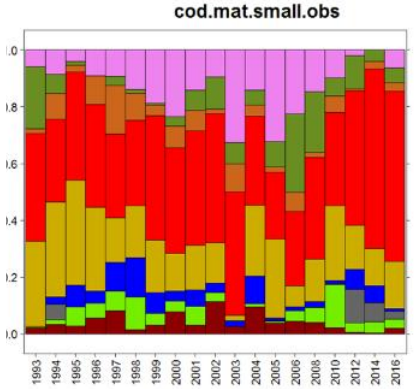


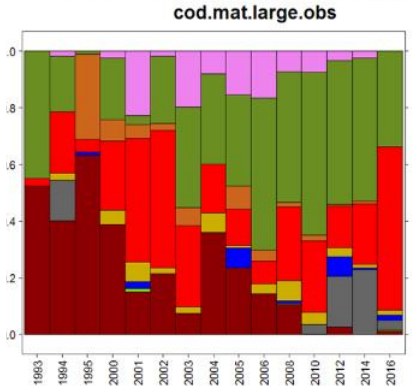
Diet composition











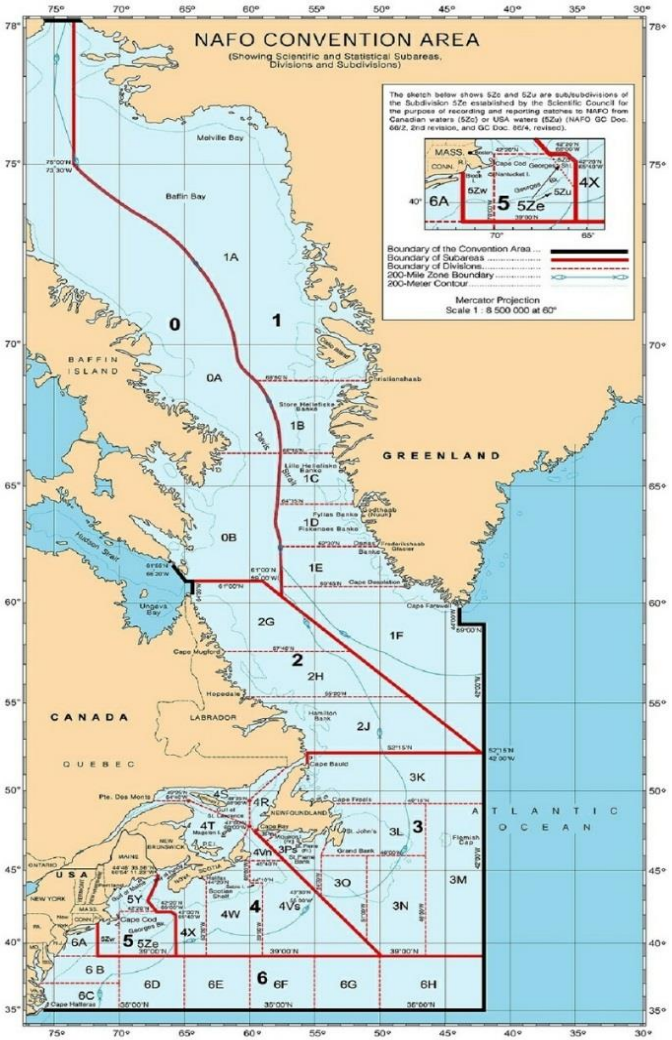
Cod preying on:

- Cod
- Redfish
- Shrimp

Redfish eating:

- Shrimp
- Redfish

NAFO and the EAF



- In 2007 amendments to the NAFO convention
- NAFO convention indicates in its preamble that *"effective conservation and management of these fishery resources should be based on the **best available scientific advice and the precautionary approach**"* while it commits to *"**apply an ecosystem approach to fisheries management** in the Northwest Atlantic that includes safeguarding the marine environment, conserving its marine biodiversity, minimizing the risk of long term or irreversible adverse effects of fishing activities, and **taking account of the relationship between all components** of the ecosystem"*.

European Maritime and Fisheries Fund
Framework Programme UE EMFF/2016/008
EU SC05 project
"Multispecies Fisheries Assessment for NAFO"

Task 2: Updating GadCap

An **updated version** of the multispecies **model GadCap**: a gadget cod, redfish an shrimp multispecies model in the Flemish Cap.

Task 3: First approach to implement multispecies assessment

Explore the provision of scientific advice for a multispecies approach in the Flemish Cap

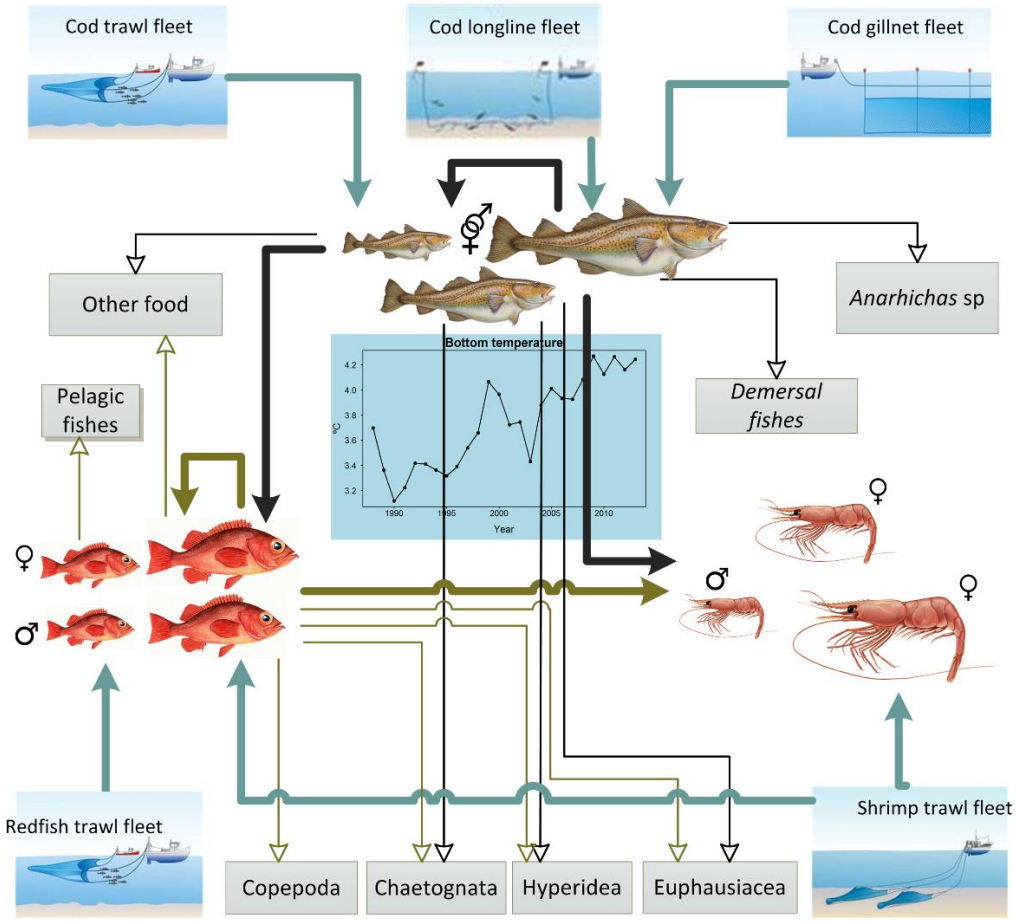
- Use of **multispecies natural mortality** estimates in single species stock assessment
- **Multispecies MSE framework and potential multispecies HCRs.**

Task 4: Economyc trade-offs

First analysis of the **socio/economic implications**

Available techniques and models needed to assess the trade-offs

Task 2 – Update and Improvement of Gadcap Multispecies Model



-**Gadget** (Globally applicable Area Dissagregated General Ecosystem Toolbox)

•Age-length based model

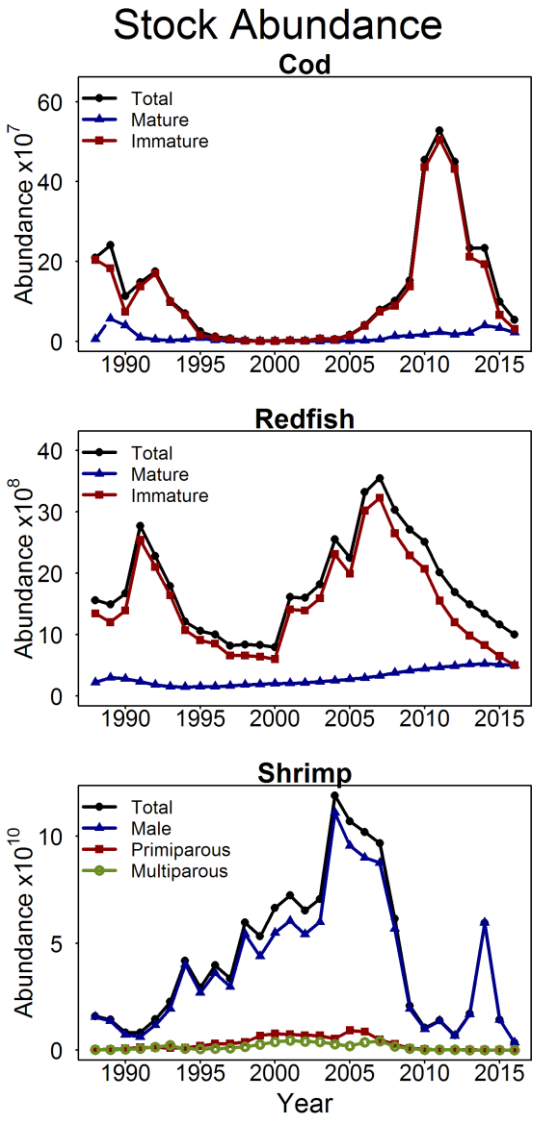
Biological processes:
•Growth
• Maturation
• Sex change
• Length-weight relationship
• Residual mortality

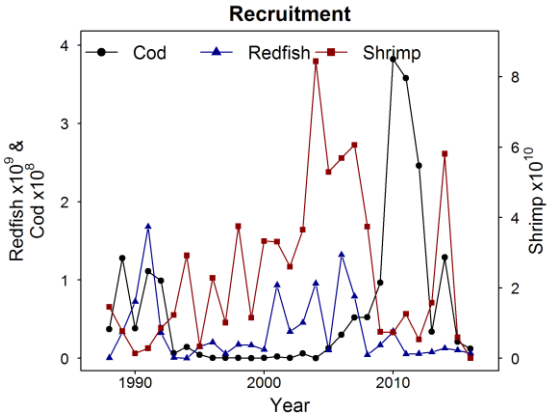
Ecology related components
•Consumption
•Diet composition
• Prey preference
•Prey-predator size relationship
• Prey-predator suitability function

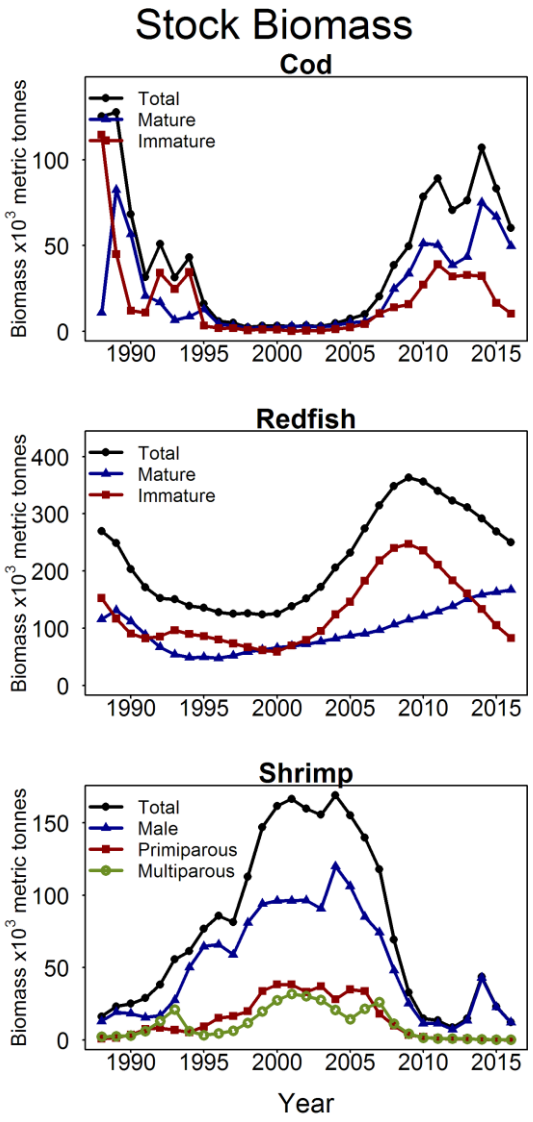
linearfleet: catches are modelled
•Trawl and longline: sigmoid
•Gillnet: dome shaped
• Redfish bycatch in shrimp fishery: dome shaped

Pérez-Rodríguez, A. and D. González Troncoso (2018). "Update of the Flemish Cap multispecies model GadCap as part of the EU SC05 project: "Multispecies Fisheries Assessment for NAFO"." NAFO SCR Doc. 18/024.

Abundance, recruitment and Biomass

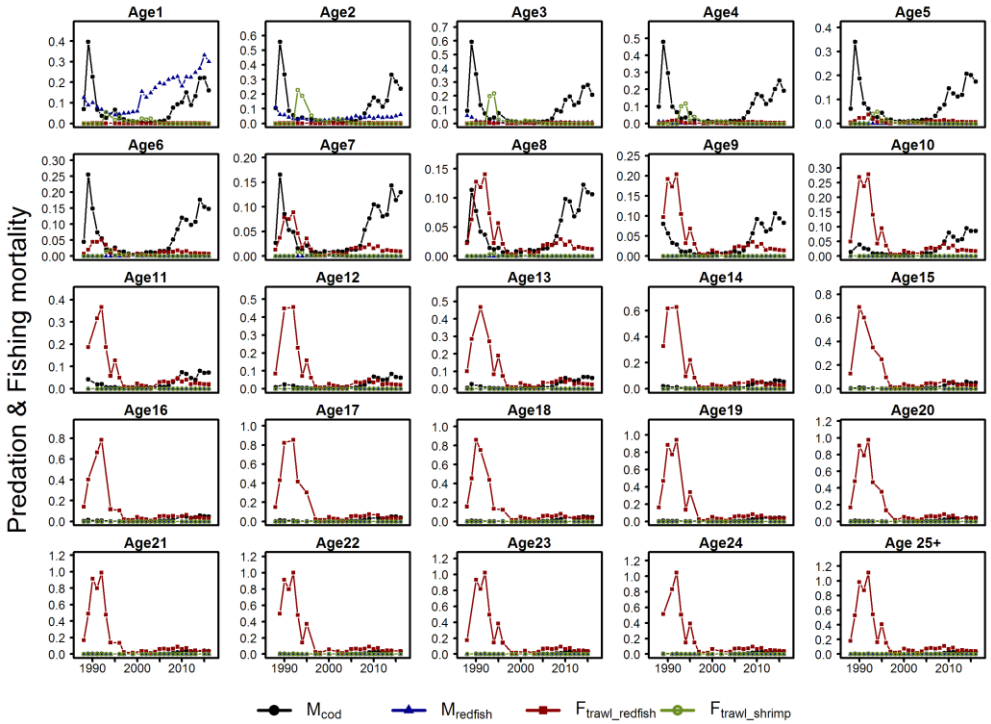




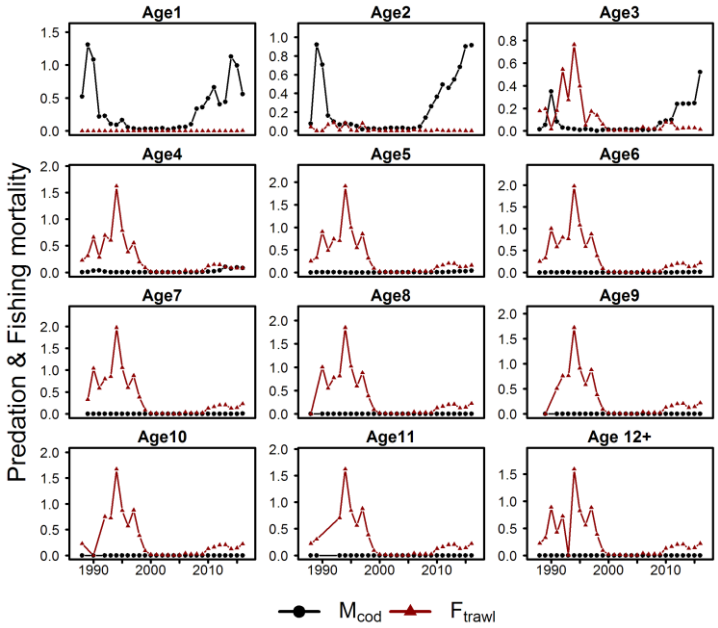


Fishing and Predation mortality at age

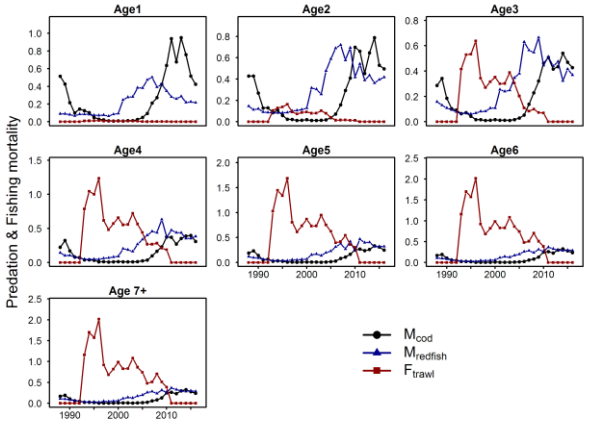
Redfish



Cod



Shrimp

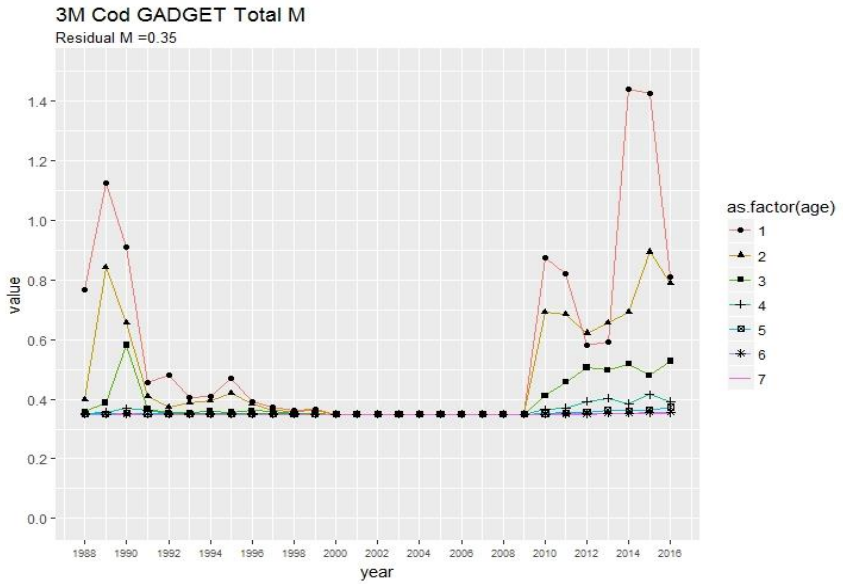


Task 3 – Application of Multispecies Approach Subtask 3.1 Estimates of natural mortality (M1+M2) and use in single species stock assessment and short term forecast

Connection with SC03: Estimates of natural predation and residual mortality for the Flemish Cap cod

- DG-MARE SC03:

"Support to a robust model assessment, benchmark and development of a management strategy evaluation for cod in NAFO division 3M"



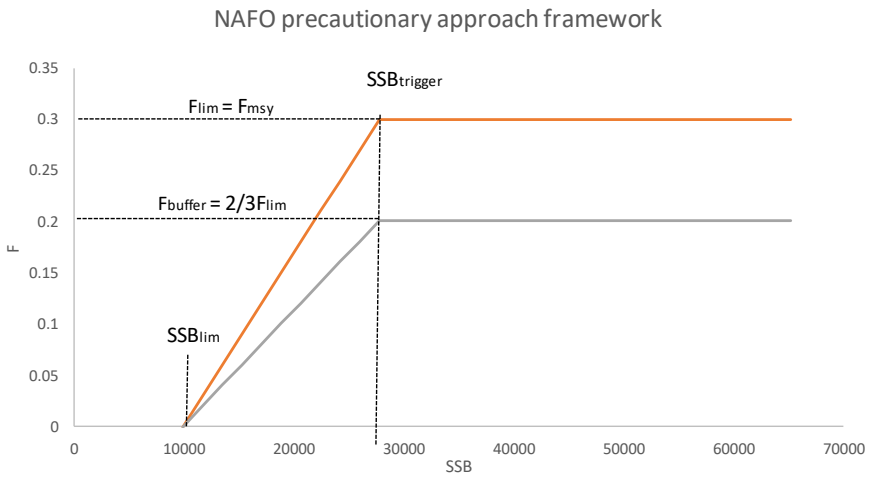
https://www.nafo.int/Portals/0/PDFs/sc/2018/scr18-025.pdf

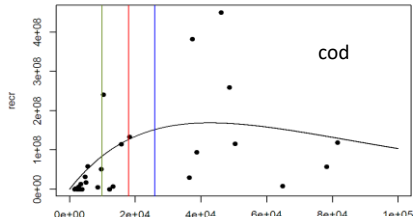
Task 3 – Application of Multispecies Approach

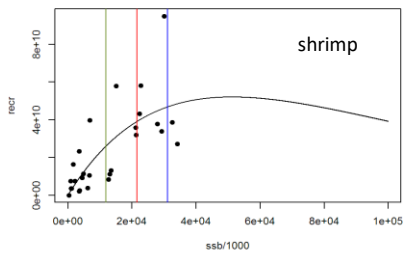
Subtask 3.2 Explore multispecies reference points and HCRs

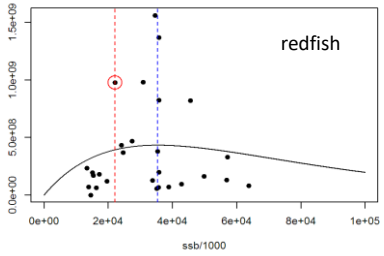
Subtask 3.3 Multispecies MSE framework

Estimating reference points: Blim and Btrigger









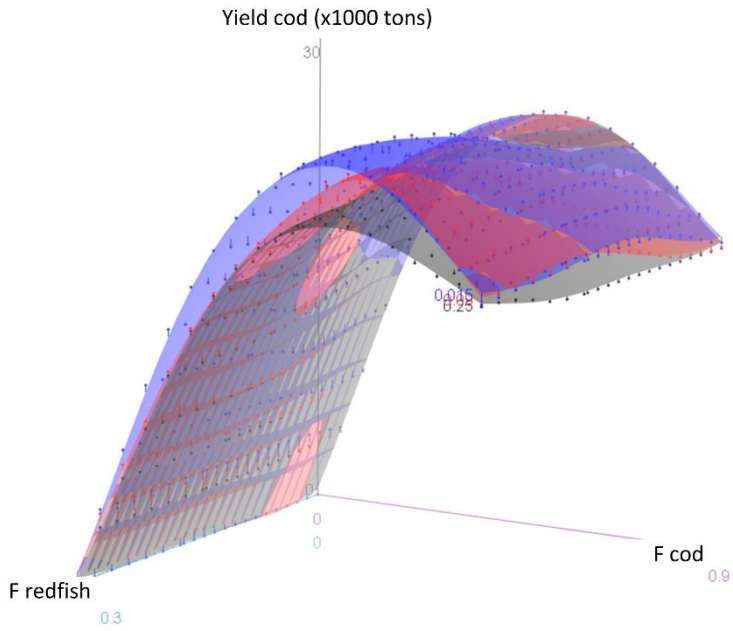
species	Blim	Btr
cod	17906	25943
redfish	22027	35361
shrimp	11864	31114

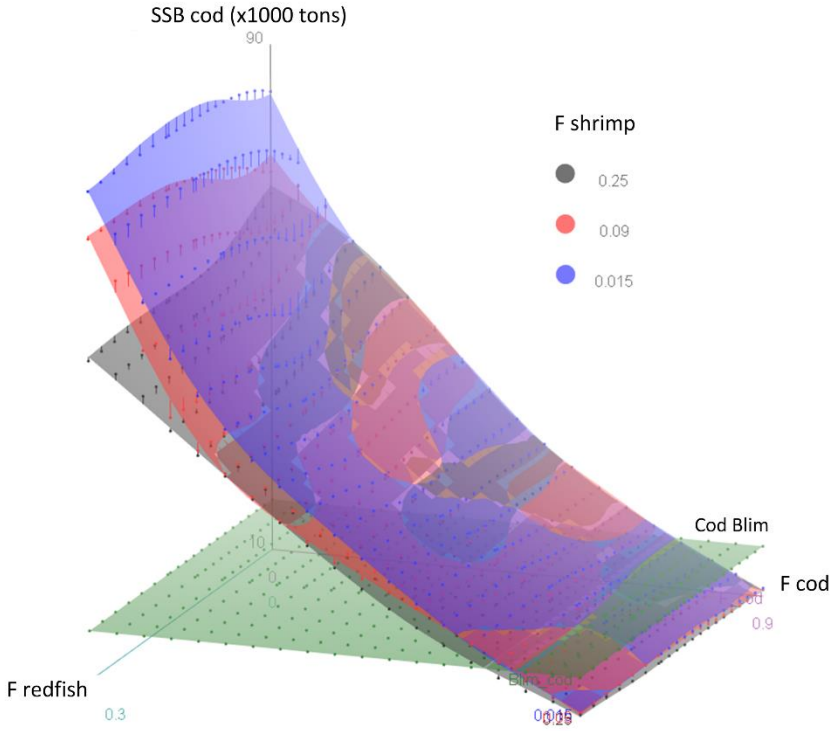
Estimate candidate multispecies F reference points
Long term projections using GadCap

- 2017-2050
- Ricker SSB-Recruitment deterministic in first place
- Only trawl fleets (cod, redfish and shrimp)
- Run 8000 F combinations (20 F values per species)
- For each combination calculate the mean SSB and yield in the period 2035-2050.

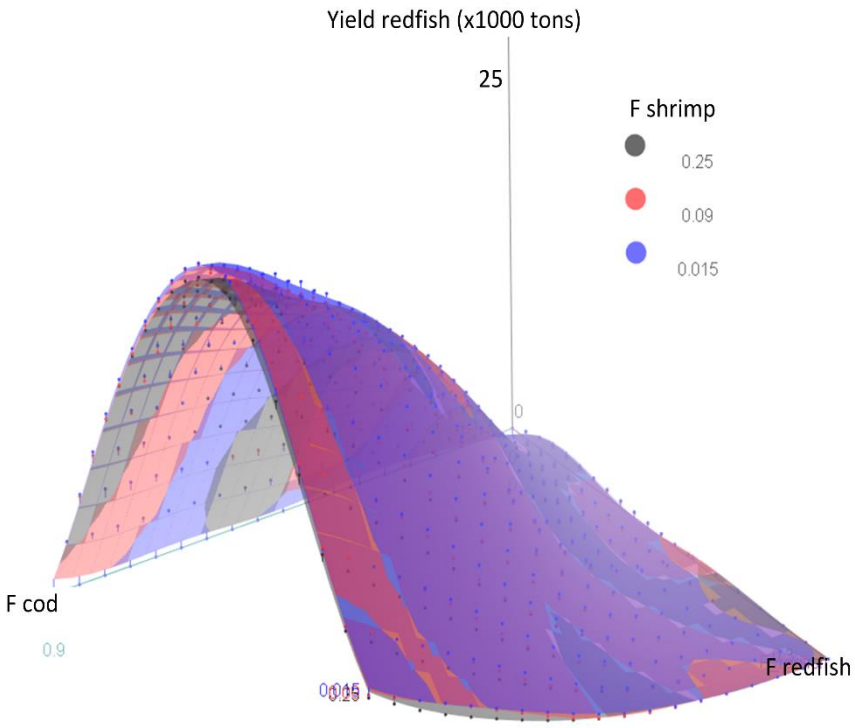
F_{cod}	F_{red}	F_{shrimp}
0	0	0
0.05	0.015	0.015
0.1	0.03	0.03
0.15	0.045	0.045
0.2	0.06	0.06
0.25	0.075	0.075
0.3	0.09	0.09
0.35	0.105	0.105
0.4	0.12	0.12
0.45	0.135	0.135
0.5	0.15	0.15
0.55	0.165	0.165
0.6	0.18	0.18
0.65	0.195	0.195
0.7	0.2	0.2
0.75	0.225	0.225
0.8	0.25	0.25
0.85	0.275	0.275
0.9	0.3	0.3
0.95	0.325	0.325

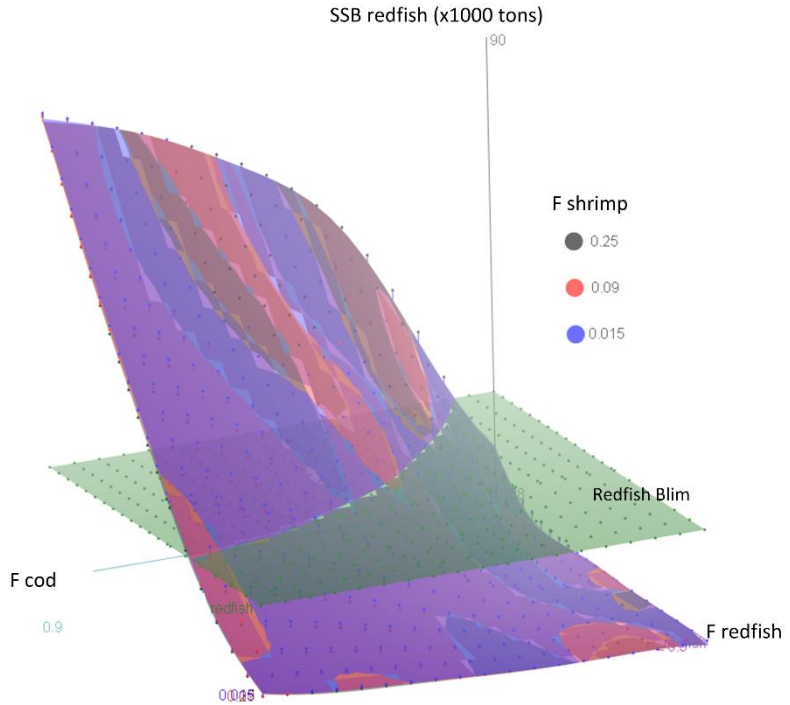
Yield and SSB curves
Cod



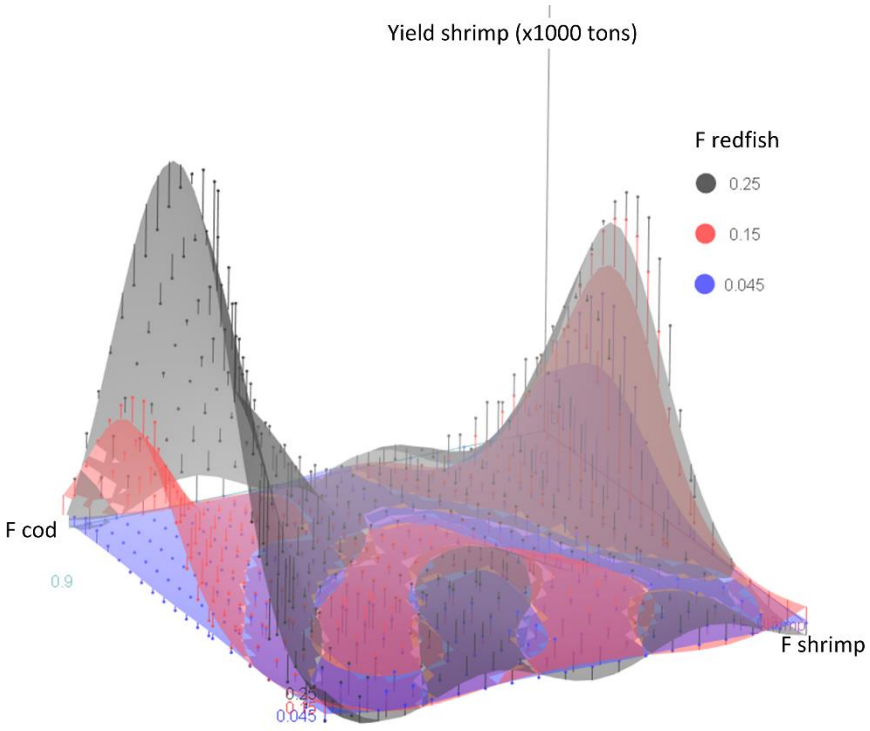


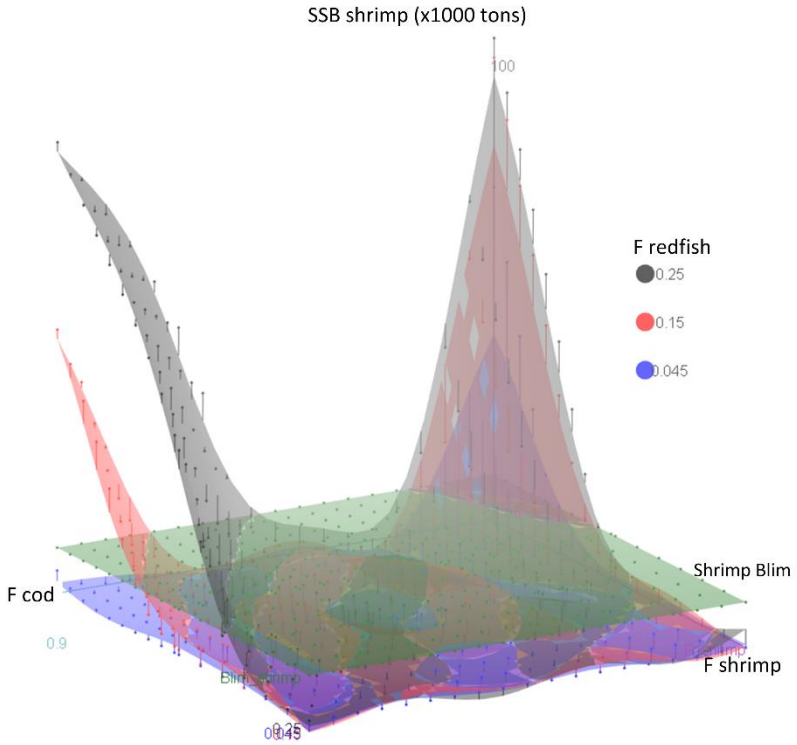
Yield and SSB curves Redfish





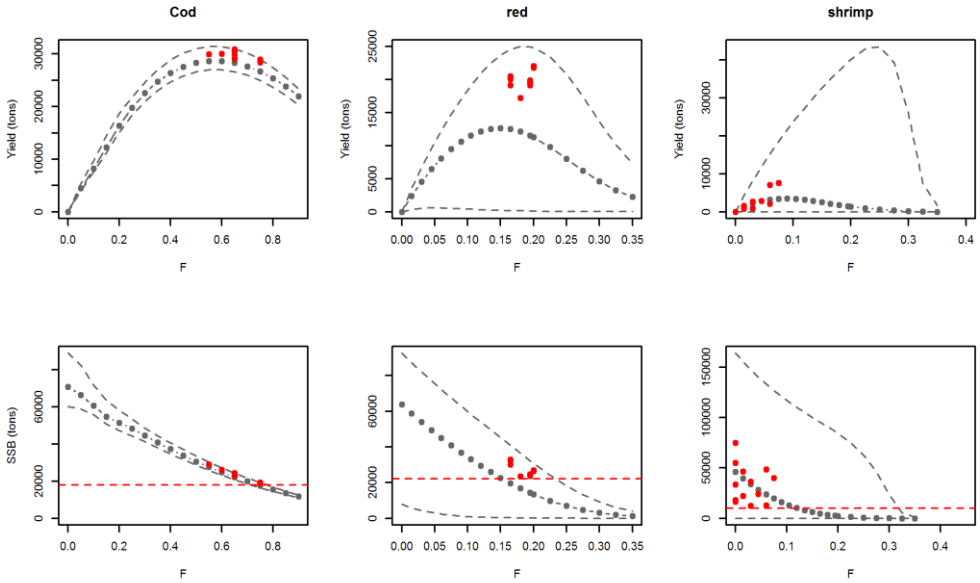
Yield and SSB curves Shrimp





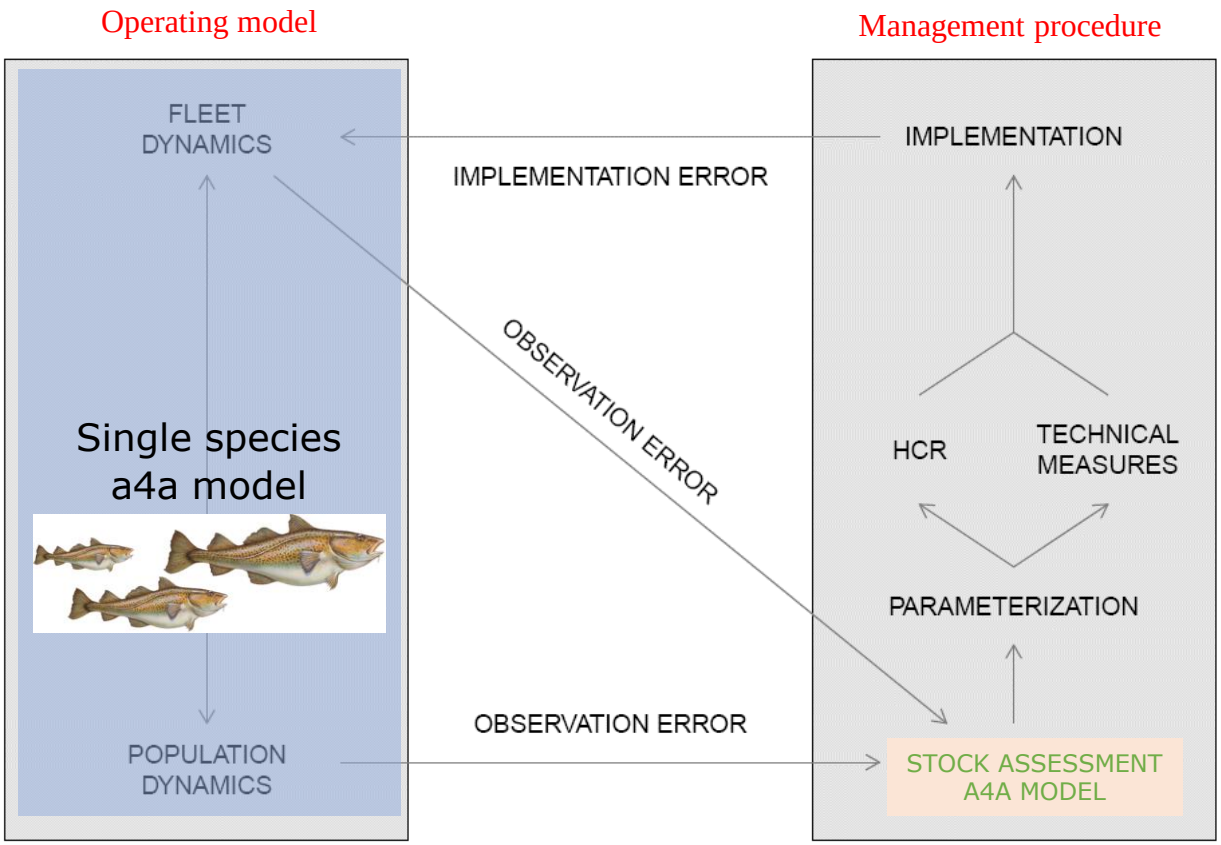
Candidate multispecies F reference values

- Find combinations of F that keep the three stocks above Blim in a Deterministic way
- Only 96 out of 8000 combinations
- Selection of 13 combinations:

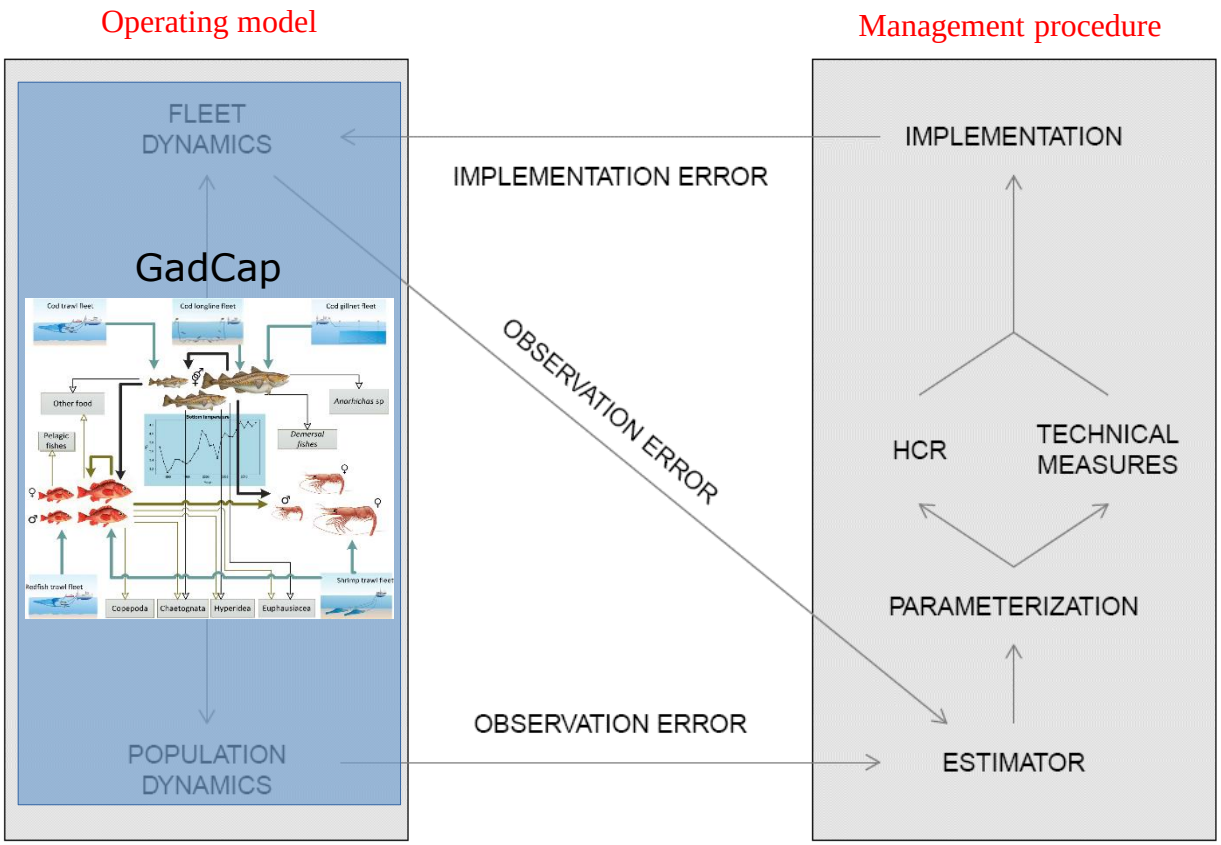


F_cod	F_redfish	F_shrimp
0.55	0.18	0
0.6	0.165	0
0.65	0.165	0
0.65	0.165	0.015
0.65	0.165	0.03
0.65	0.195	0
0.65	0.195	0.015
0.65	0.195	0.03
0.65	0.195	0.045
0.65	0.195	0.06
0.75	0.2	0
0.75	0.2	0.06
0.75	0.2	0.075

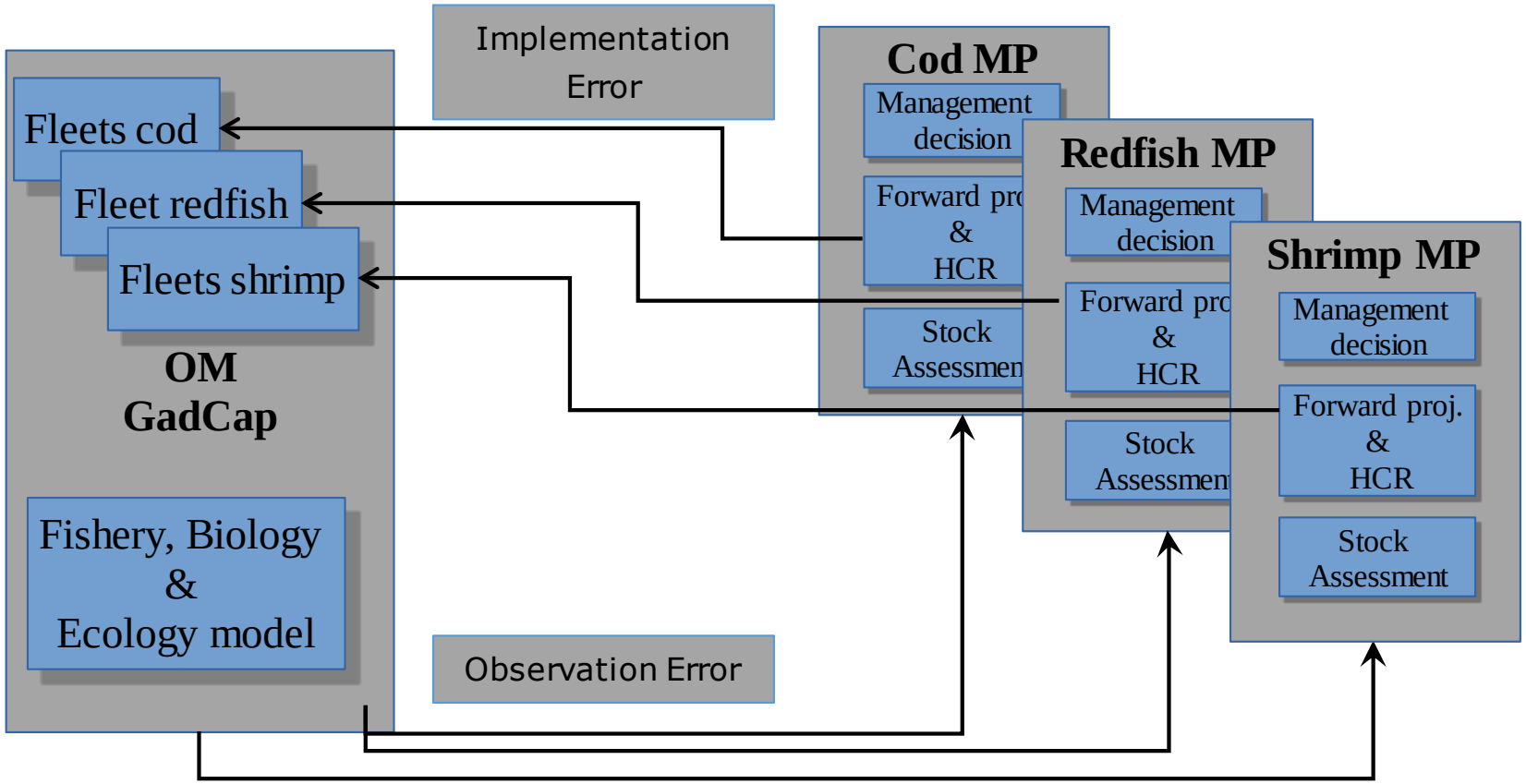
a4a-FLR MSE framework: EU JRC (Ispra)



Adapting a4a-FLR MSE framework: GadCap as operating model

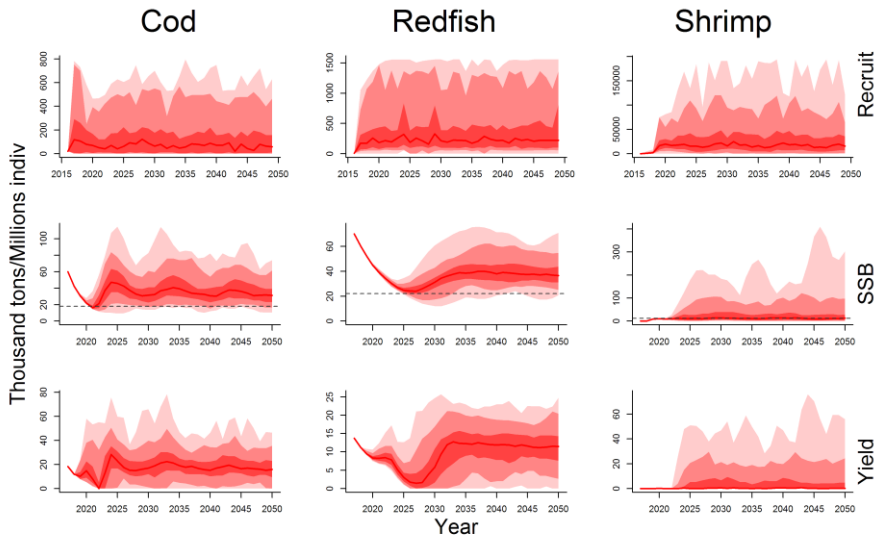


Adapting a4a-FLR MSE framework: GadCap as operating model

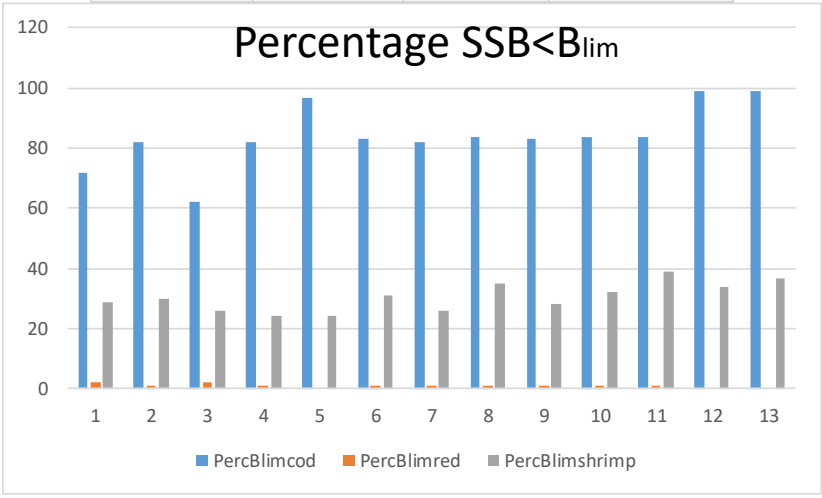


Stock assessment
- Shortcut (assessment error)
- SCAA a4a

Risk analysis with recruitment uncertainty
Multispecies F candidates



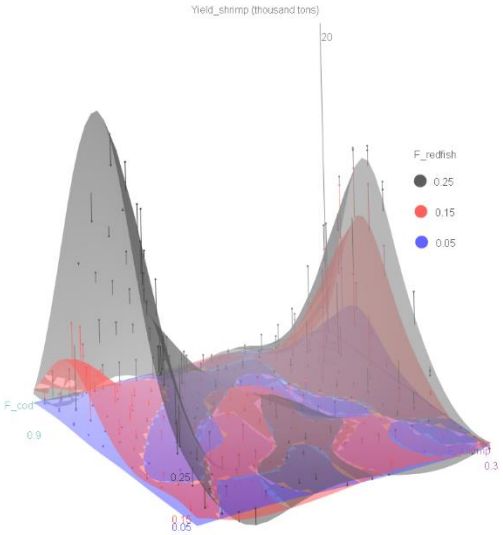
combination	Ftargetcod	Ftargetred	Ftargetshrimp
1	0.6	0.165	0
2	0.65	0.165	0
3	0.55	0.18	0
4	0.65	0.195	0
5	0.75	0.2	0
6	0.65	0.165	0.015
7	0.65	0.195	0.015
8	0.65	0.165	0.03
9	0.65	0.195	0.03
10	0.65	0.195	0.045
11	0.65	0.195	0.06
12	0.75	0.2	0.06
13	0.75	0.2	0.075

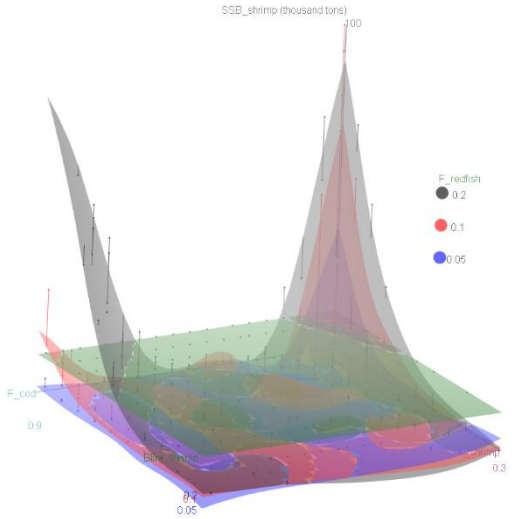


- Very **similar pattern for all the 13 F combinations**:
- The F values required to keep all the three species above Blim in a deterministic way entails a very **high risk of collapse** when recruitment uncertainty is considered
- High risk SSBcod<Blim
- Low risk SSBredfish<Blim (But not in medium term)
- High risk SSBshrimp<Blim

Risk analysis with recruitment uncertainty
Multispecies F candidates

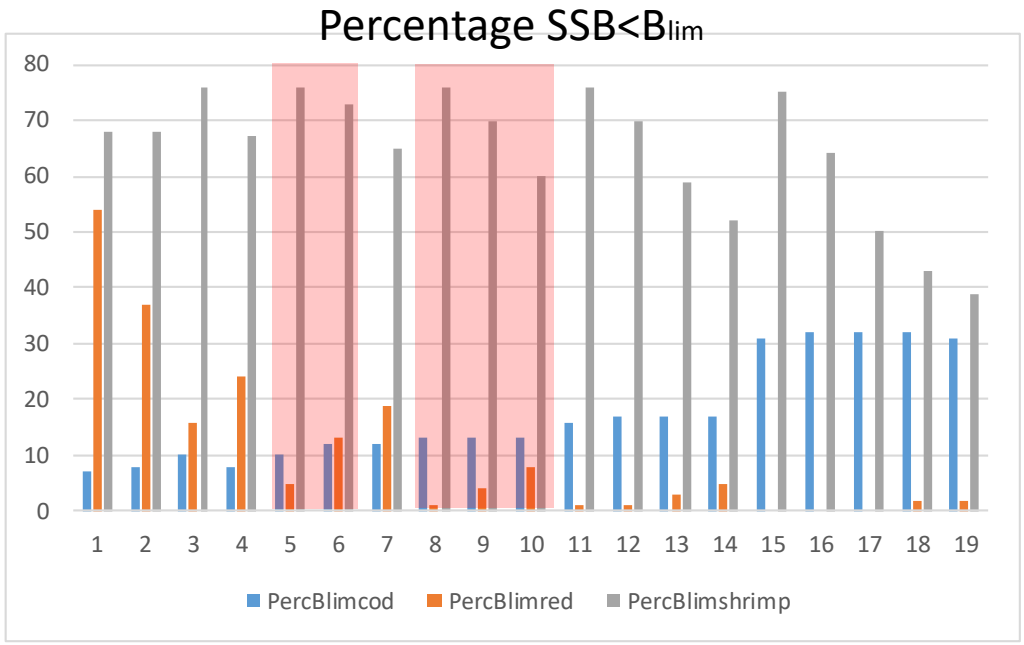
- High predation pressure of cod and redfish on shrimp → only very high fishing mortality on these stocks ensure shrimp above Blim





- Conclusion: The **three species cannot be maintained above Blim** at the same time.
- Next step: New **simulations disregarding each of the three stocks one by one** in terms of maintaining above Blim.

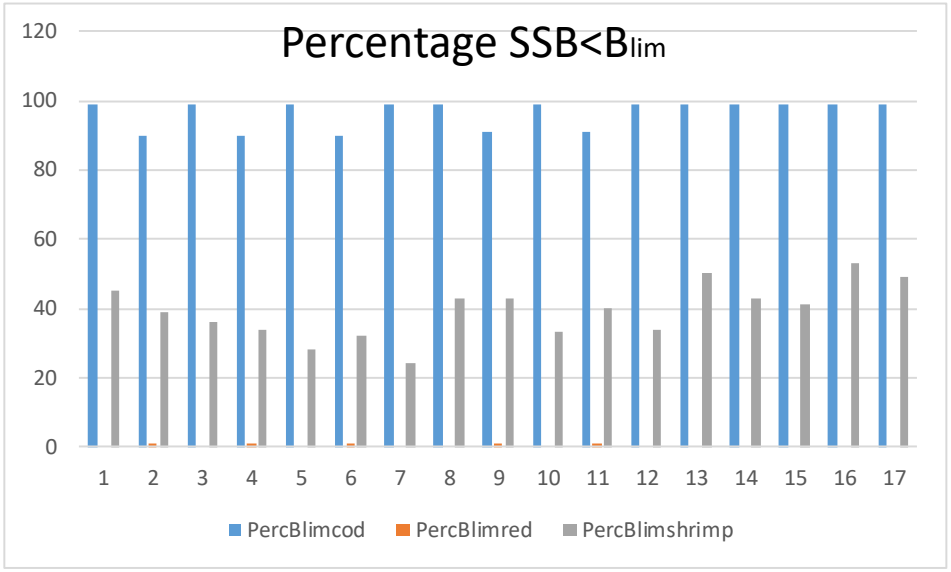
Risk analysis
Multispecies HCRs disregarding shrimp



Combination	Ftargetcod	Ftargetred	Ftargetshrimp
1	0.1	0	0
2	0.15	0.03	0
3	0.2	0.03	0
4	0.2	0.06	0
5	0.25	0.03	0
6	0.25	0.06	0
7	0.25	0.09	0
8	0.3	0.03	0
9	0.3	0.06	0
10	0.3	0.09	0
11	0.35	0.03	0
12	0.35	0.06	0
13	0.35	0.09	0
14	0.35	0.12	0
15	0.45	0.03	0
16	0.45	0.06	0
17	0.45	0.09	0
18	0.45	0.12	0
19	0.45	0.15	0

- A few combinations of F for cod and redfish that reduce the likelihood of SSB being below Blim more than 10-15 percent.

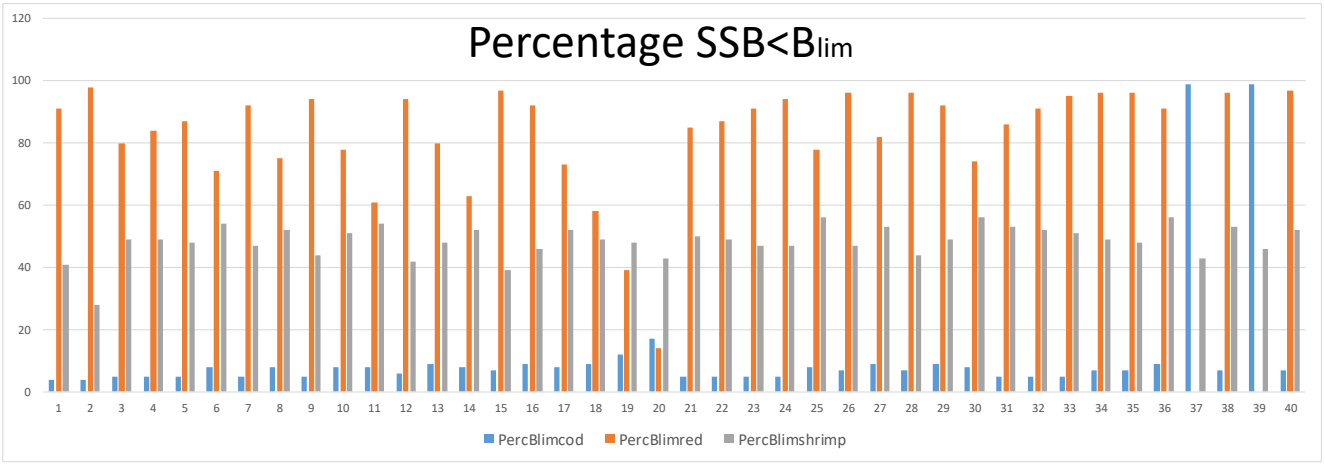
Risk analysis
Multispecies HCRs disregarding cod



Combination	Ftargetcod	Ftargetred	Ftargetshrimp
1	0.8	0.12	0.03
2	0.7	0.15	0.03
3	0.8	0.15	0.03
4	0.7	0.18	0.03
5	0.8	0.18	0.03
6	0.7	0.2	0.03
7	0.8	0.2	0.03
8	0.8	0.15	0.06
9	0.7	0.18	0.06
10	0.8	0.18	0.06
11	0.7	0.2	0.06
12	0.8	0.2	0.06
13	0.8	0.15	0.09
14	0.8	0.18	0.09
15	0.8	0.2	0.09
16	0.8	0.18	0.12
17	0.8	0.2	0.12

- Risk of collapse on redfish was almost null, while for cod and shrimp it was very high

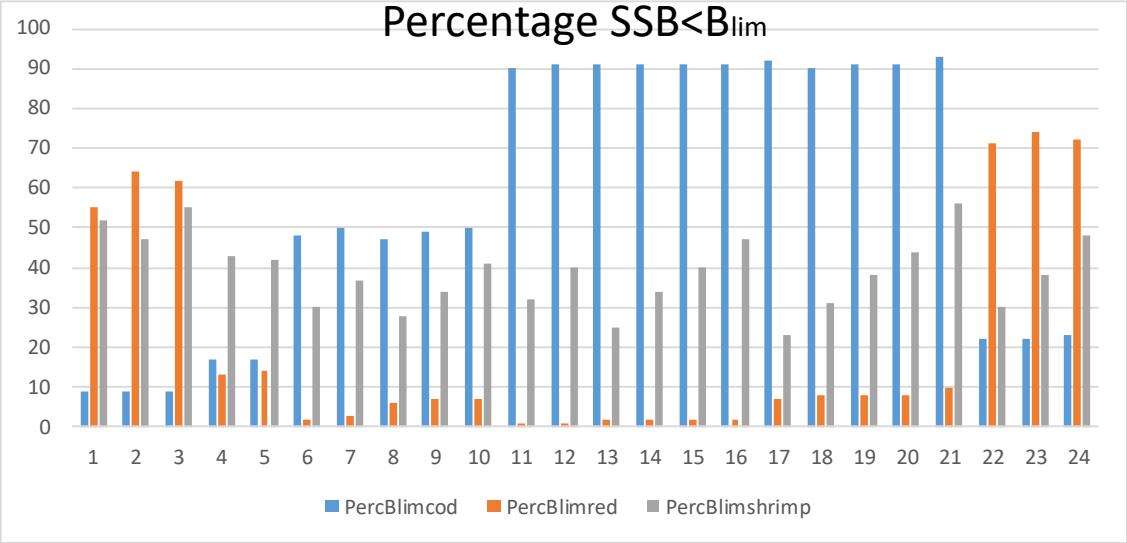
Risk analysis
Multispecies HCRs disregarding redfish



combination	Ftargetcod	Ftargetred	Ftargetshrimp
1	0	0	0
2	0	0.195	0
3	0.05	0.03	0.03
4	0.05	0.06	0.03
5	0.05	0.09	0.03
6	0.1	0.09	0.03
7	0.05	0.12	0.03
8	0.1	0.12	0.03
9	0.05	0.15	0.03
10	0.1	0.15	0.03
11	0.15	0.15	0.03
12	0.05	0.2	0.03
13	0.1	0.2	0.03
14	0.15	0.2	0.03
15	0.05	0.3	0.03
16	0.1	0.3	0.03
17	0.15	0.3	0.03
18	0.2	0.3	0.03
19	0.25	0.3	0.03
20	0.35	0.3	0.03
21	0.05	0.06	0.06
22	0.05	0.09	0.06
23	0.05	0.12	0.06
24	0.05	0.15	0.06
25	0.1	0.15	0.06
26	0.05	0.2	0.06
27	0.1	0.2	0.06
28	0.05	0.3	0.06
29	0.1	0.3	0.06
30	0.15	0.3	0.06
31	0.05	0.09	0.09
32	0.05	0.12	0.09
33	0.05	0.15	0.09
34	0.05	0.2	0.09
35	0.05	0.3	0.09
36	0.1	0.3	0.09
37	0.75	0.25	0.105
38	0.05	0.2	0.12
39	0.75	0.275	0.12
40	0.05	0.3	0.12

- Risk of collapse on cod was very low in most HCRs combinations, while for redfish and shrimp it was very high

Risk analysis
Multispecies HCRs disregarding cod and redfish

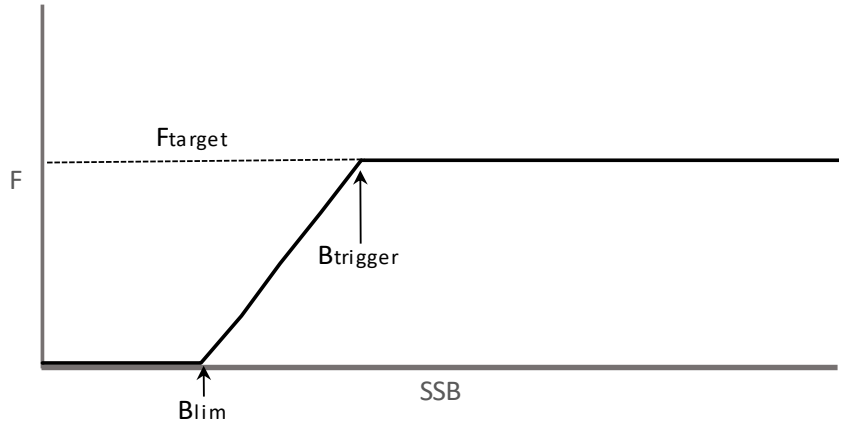


Combination	Ftargetcod	Ftargetred	Ftargetshrimp
1	0.2	0.275	0.03
2	0.2	0.35	0.03
3	0.2	0.35	0.06
4	0.35	0.275	0.03
5	0.35	0.35	0.03
6	0.5	0.275	0.03
7	0.5	0.275	0.06
8	0.5	0.35	0.03
9	0.5	0.35	0.06
10	0.5	0.35	0.09
11	0.7	0.2	0.03
12	0.7	0.2	0.06
13	0.7	0.275	0.03
14	0.7	0.275	0.06
15	0.7	0.275	0.09
16	0.7	0.275	0.12
17	0.7	0.35	0.03
18	0.7	0.35	0.06
19	0.7	0.35	0.09
20	0.7	0.35	0.12
21	0.7	0.35	0.18
22	0.4	0.5	0.03
23	0.4	0.5	0.06
24	0.4	0.5	0.09

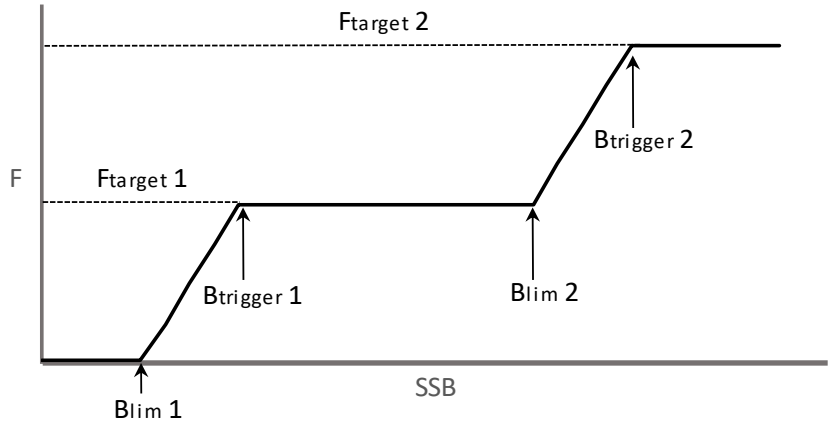
- Risk of collapse on cod and redfish showed an opposite pattern, while risk of collapse for shrimp was always high

Two stages HCR: avoid excessive predation?

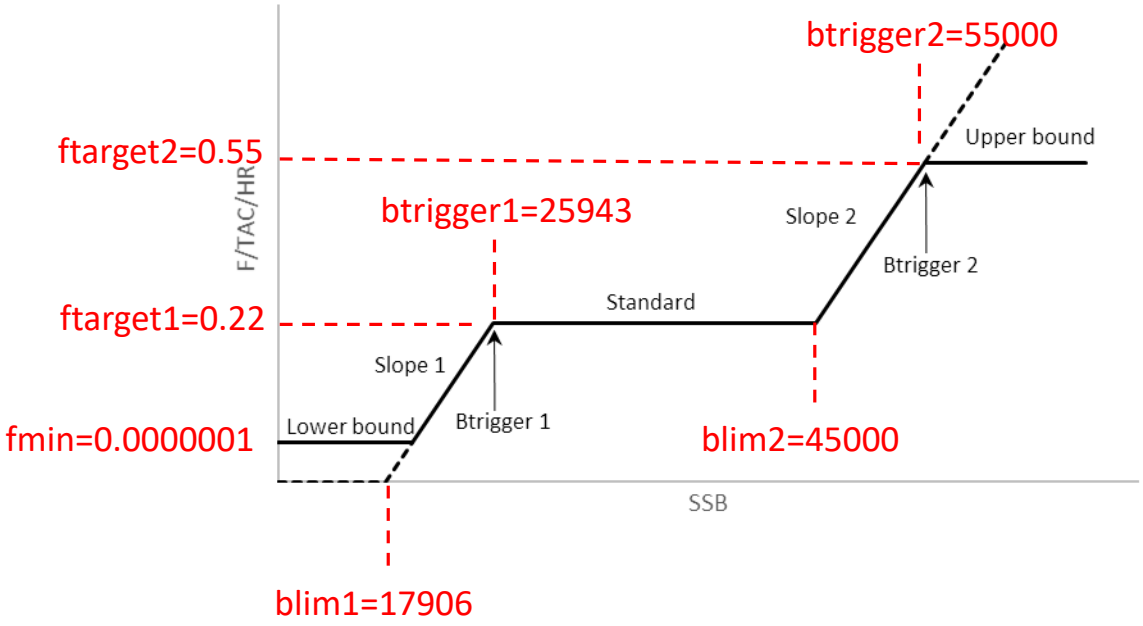
Single stage hockey stick HCR



Double stage hockey stick HCR



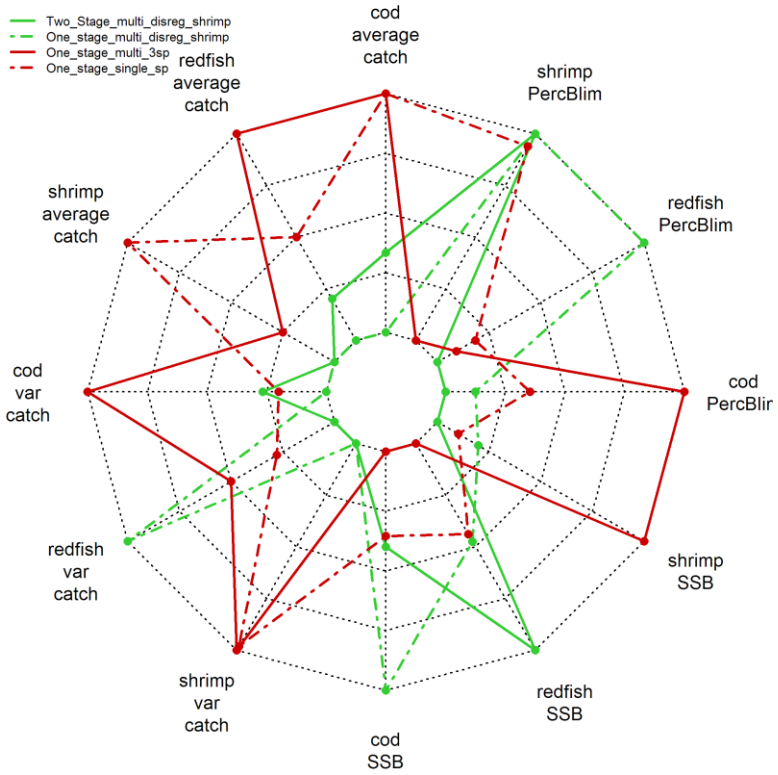
Two stages HCR: avoid excessive predation?

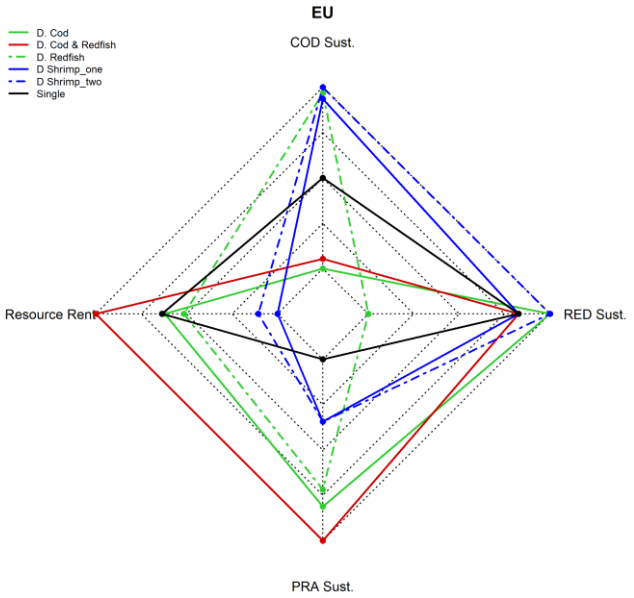


Two stages HCR: avoid excessive predation?

		F_{target}		Perc_B_{lim}_cod		Perc_B_{lim}_redfish		Perc_B_{lim}_shrimp	
comb.N	cod	redfish	shrimp	one-stage	two-stage	one-stage	two-stage	one-stage	two-stage
1	0.25	0.03	0	13	10	6	0	82	82
2	0.25	0.06	0	14	11	15	0	73	75
3	0.25	0.09	0	14	12	23	2	67	65
4	0.35	0.12	0	27	28	6	2	58	54

Trade-offs assessment

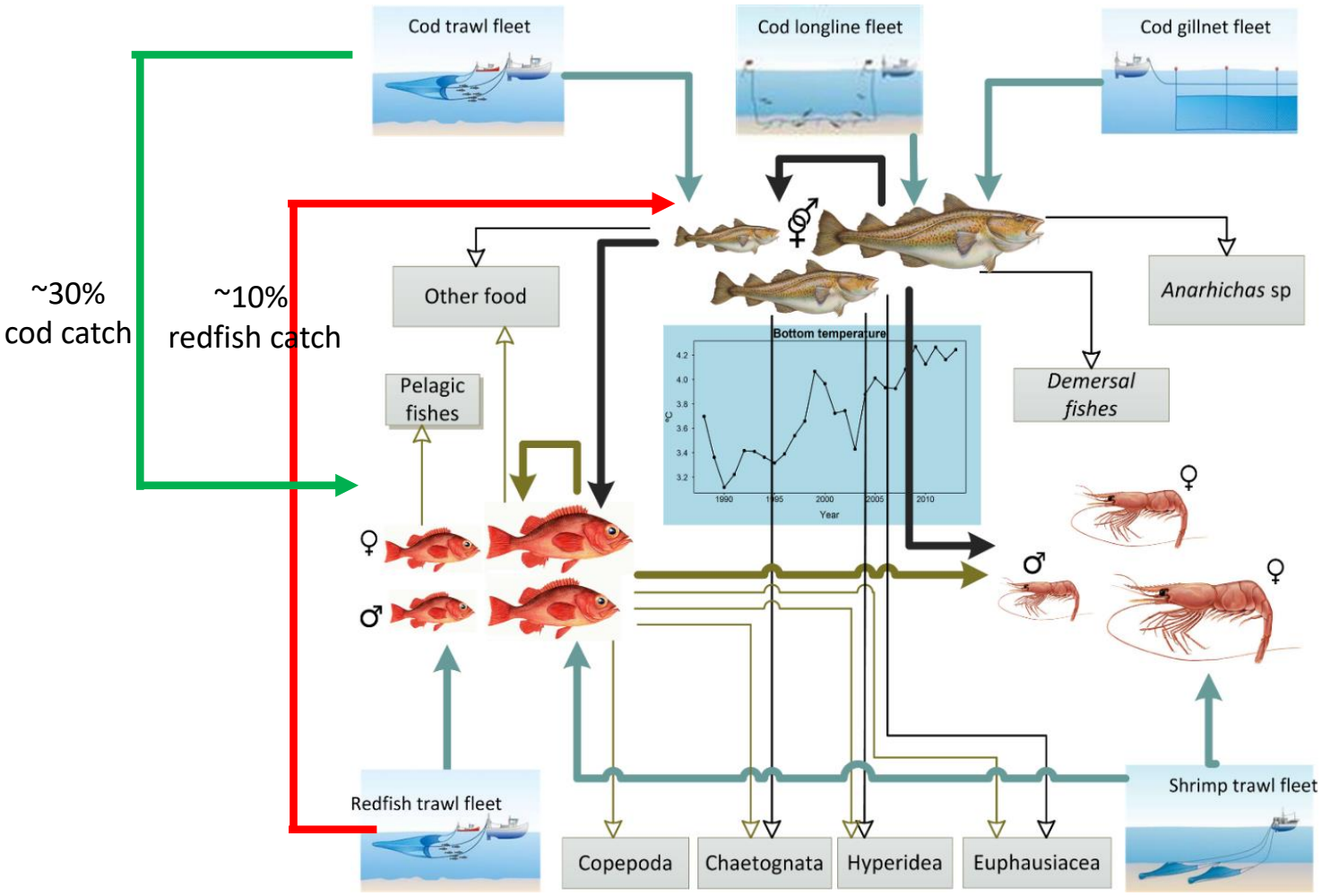




Conclusions

- The results suggest that it is not possible having the 3 sps above Blim
- Disregarding one stock may allow finding precautionary multispecies reference points for the others.
- Precautionary HCRs for two stocks at once were only found when shrimp SSB in relation to Blim was disregarded.
- The results suggest that the two stages HCRs for cod reduces predation and increases probability of cod, redfish being above Blim.

Technical interactions



Ecological-Technical multispecies interactions and the next generation assessment models

Are ecological-technical interactions needed in the general model or are they better accomplished outside the general model?

- Benefits of creating MICE general model (with capacity for multispecies interactions)
  - Stock assessment model
  - Simulation model (OM within MSE)

Are ecological-technical interactions needed in the general model or are they better accomplished outside the general model?

- Application of MICE with multispecies interactions
  - Stock assessment

N at age

Age/Year	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
1	674	1325	1173	4043	3262	219	405	170	11	9	16	2	43	102	10	265	8	589	954	1290	1160	1661	2910	4767	3852	587	1313	336	28	375	84
2	1469	164	322	285	981	801	53	99	41	3	2	4	1	11	25	2	65	2	144	235	317	284	405	710	1169	943	143	321	82	7	92
3	987	769	86	169	149	457	392	23	44	21	1	1	2	0	6	13	1	35	1	76	125	169	151	214	377	620	500	76	170	43	4
4	308	487	375	41	87	39	162	102	10	24	8	1	1	1	0	4	9	1	24	1	53	85	115	97	135	246	402	335	50	112	29
5	44	132	170	116	19	15	10	22	18	4	8	5	0	0	1	0	3	7	1	18	1	39	64	78	66	96	175	283	237	35	81
6	10	18	49	52	51	3	4	2	3	7	1	4	3	0	0	1	0	2	5	0	13	0	29	40	48	44	64	121	195	163	24
7	7	3	6	10	20	8	0	1	0	1	1	0	2	2	0	0	0	0	2	4	0	9	0	17	21	27	25	38	70	119	99
8+	3	3	2	2	4	2	3	1	0	0	0	0	0	2	3	2	1	1	1	2	4	3	8	5	10	17	24	27	37	62	108

Are ecological-technical interactions needed in the general model or are they better accomplished outside the general model?

- Application of MICE with multispecies interactions
  - Stock assessment model

N at age

Age/Year	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
1	674	1325	1173	4043	3262	219	405	170	11	9	16	2	43	102	10	265	8	589	954	1290	1160	1661	2910	4767	3852	587	1313	336	28	375	84
2	1469	164	322	285	981	801	53	99	41	3	2	4	1	11	25	2	65	2	144	235	317	284	405	710	1169	943	143	321	82	7	92
3	987	769	86	169	149	457	392	23	44	21	1	1	2	0	6	13	1	35	1	76	125	169	151	214	377	620	500	76	170	43	4
4	308	487	375	41	87	39	162	102	10	24	8	1	1	1	0	4	9	1	24	1	53	85	115	97	135	246	402	335	50	112	29
5	44	132	170	116	19	15	10	22	18	4	8	5	0	0	1	0	3	7	1	18	1	39	64	78	66	96	175	283	237	35	81
6	10	18	49	52	51	3	4	2	3	7	1	4	3	0	0	1	0	2	5	0	13	0	29	40	48	44	64	121	195	163	24
7	7	3	6	10	20	8	0	1	0	1	1	0	2	2	0	0	0	0	2	4	0	9	0	17	21	27	25	38	70	119	99
8+	3	3	2	2	4	2	3	1	0	0	0	0	0	2	3	2	1	1	1	2	4	3	8	5	10	17	24	27	37	62	108

Are ecological-technical interactions needed in the general model or are they better accomplished outside the general model?

- Application of MICE with multispecies interactions
  - Stock assessment model

N at age

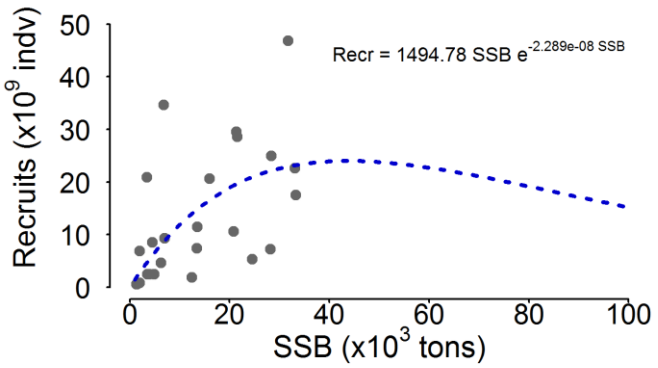
Age/Year	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
1	674	1325	1173	4043	3262	219	405	170	11	9	16	2	43	102	10	265	8	589	954	1290	1160	1661	2910	4767	3852	587	1313	336	28	375	84
2	1469	164	322	285	981	801	53	99	41	3	2	4	1	11	25	2	65	2	144	235	317	284	405	710	1169	943	143	321	82	7	92
3	987	769	86	169	149	457	392	23	44	21	1	1	2	0	6	13	1	35	1	76	125	169	151	214	377	620	500	76	170	43	4
4	308	487	375	41	87	39	162	102	10	24	8	1	1	1	0	4	9	1	24	1	53	85	115	97	135	246	402	335	50	112	29
5	44	132	170	116	19	15	10	22	18	4	8	5	0	0	1	0	3	7	1	18	1	39	64	78	66	96	175	283	237	35	81
6	10	18	49	52	51	3	4	2	3	7	1	4	3	0	0	1	0	2	5	0	13	0	29	40	48	44	64	121	195	163	24
7	7	3	6	10	20	8	0	1	0	1	1	0	2	2	0	0	0	0	2	4	0	9	0	17	21	27	25	38	70	119	99
8+	3	3	2	2	4	2	3	1	0	0	0	0	0	2	3	2	1	1	1	2	4	3	8	5	10	17	24	27	37	62	108

Are ecological-technical interactions needed in the general model or are they better accomplished outside the general model?

- Application of MICE with multispecies interactions
  - Stock assessment model

N at age

Age/Year	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
1	674	1325	1173	4043	3262	219	405	170	11	9	16	2	43	102	10	265	8	589	954	1290	1160	1661	2910	4767	3852	587	1313	336	28	375	84
2	1469	164	322	285	981	801	53	99	41	3	2	4	1	11	25	2	65	2	144	235	317	284	405	710	1169	943	143	321	82	7	92
3	987	769	86	169	149	457	392	23	44	21	1	1	2	0	6	13	1	35	1	76	125	169	151	214	377	620	500	76	170	43	4
4	308	487	375	41	87	39	162	102	10	24	8	1	1	1	0	4	9	1	24	1	53	85	115	97	135	246	402	335	50	112	29
5	44	132	170	116	19	15	10	22	18	4	8	5	0	0	1	0	3	7	1	18	1	39	64	78	66	96	175	283	237	35	81
6	10	18	49	52	51	3	4	2	3	7	1	4	3	0	0	1	0	2	5	0	13	0	29	40	48	44	64	121	195	163	24
7	7	3	6	10	20	8	0	1	0	1	1	0	2	2	0	0	0	0	2	4	0	9	0	17	21	27	25	38	70	119	99
8+	3	3	2	2	4	2	3	1	0	0	0	0	0	2	3	2	1	1	1	2	4	3	8	5	10	17	24	27	37	62	108

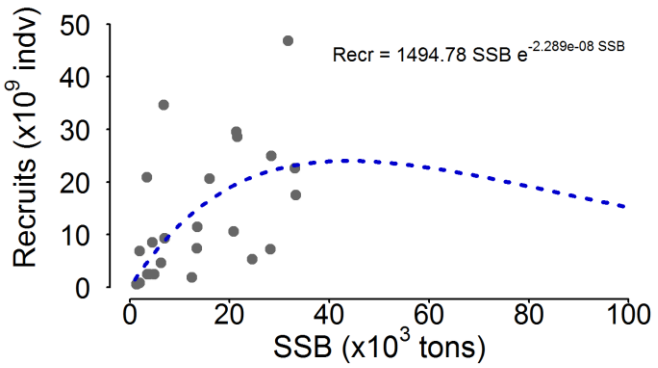


Are ecological-technical interactions needed in the general model or are they better accomplished outside the general model?

- Application of MICE with multispecies interactions
  - Stock assessment model

N at age

Age/Year	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
1	674	1325	1173	4043	3262	219	405	170	11	9	16	2	43	102	10	265	8	589	954	1290	1160	1661	2910	476	3852	587	1313	336	28	375	84			
2	1469	164	322	285	981	801	53	99	41	3	2	4	1	11	25	2	65	2	144	235	317	284	405	710	1169	943	143	321	82	7	92			
3	987	769	86	169	149	457	392	23	44	21	1	1	2	0	6	13	1	35	1	76	125	169	151	214	377	620	500	76	170	43	4			
4	308	487	375	41	87	39	162	102	10	24	8	1	1	1	0	4	9	1	24	1	53	85	115	97	135	246	402	335	50	112	29			
5	44	132	170	116	19	15	10	22	18	4	8	5	0	0	1	0	3	7	1	18	1	39	64	78	66	96	175	283	237	35	81			
6	10	18	49	52	51	3	4	2	3	7	1	4	3	0	0	1	0	2	5	0	13	0	29	40	48	44	64	121	195	163	24			
7	7	3	6	10	20	8	0	1	0	1	1	0	2	2	0	0	0	0	2	4	0	9	0	17	21	27	25	38	70	119	99			
8+	3	3	2	2	4	2	3	1	0	0	0	0	0	2	3	2	1	1	1	2	4	3	8	5	10	17	24	27	37	62	108			



- Although we can also asume for example recruitment as the average in the previous 3 years

Are ecological-technical interactions needed in the general model or are they better accomplished outside the general model?

- Application of MICE with multispecies interactions
  - Stock assessment model

N at age

Age/Year	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
1	674	1325	1173	4043	3262	219	405	170	11	9	16	2	43	102	10	265	8	589	954	1290	1160	1661	2910	4767	3852	587	1313	336	28	375	84			
2	1469	164	322	285	981	801	53	99	41	3	2	4	1	11	25	2	65	2	144	235	317	284	405	710	1169	943	143	321	82	7	92			
3	987	769	86	169	149	457	392	23	44	21	1	1	2	0	6	13	1	35	1	76	125	169	151	214	377	620	500	76	170	43	4			
4	308	487	375	41	87	39	162	102	10	24	8	1	1	1	0	4	9	1	24	1	53	85	115	97	135	246	402	335	50	112	29			
5	44	132	170	116	19	15	10	22	18	4	8	5	0	0	1	0	3	7	1	18	1	39	64	78	66	96	175	283	237	35	81			
6	10	18	49	52	51	3	4	2	3	7	1	4	3	0	0	1	0	2	5	0	13	0	29	40	48	44	64	121	195	163	24			
7	7	3	6	10	20	8	0	1	0	1	1	0	2	2	0	0	0	0	2	4	0	9	0	17	21	27	25	38	70	119	99			
8+	3	3	2	2	4	2	3	1	0	0	0	0	0	2	3	2	1	1	1	2	4	3	8	5	10	17	24	27	37	62	108			

Use of M from multispecies model will give a different estimated N at age in the assessment period

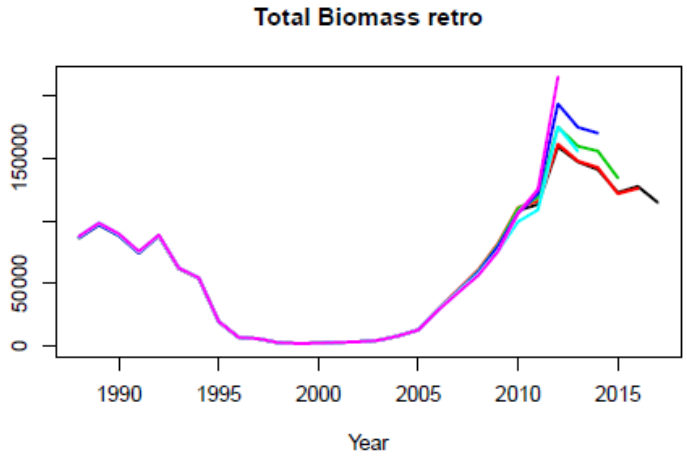
But it Will be specially important in the projections for catch advice

Are ecological-technical interactions needed in the general model or are they better accomplished outside the general model?

- Application of MICE with multispecies interactions
  - Stock assessment model

N at age

Age/Year	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
1	674	1325	1173	4043	3262	219	405	170	11	9	16	2	43	102	10	265	8	589	954	1290	1160	1661	2910	4767	3852	587	1313	336	28	375	84			
2	1469	164	322	285	981	801	53	99	41	3	2	4	1	11	25	2	65	2	144	235	317	284	405	710	1169	943	143	321	82	7	92			
3	987	769	86	169	149	457	392	23	44	21	1	1	2	0	6	13	1	35	1	76	125	169	151	214	377	620	500	76	170	43	4			
4	308	487	375	41	87	39	162	102	10	24	8	1	1	1	0	4	9	1	24	1	53	85	115	97	135	246	402	335	50	112	29			
5	44	132	170	116	19	15	10	22	18	4	8	5	0	0	1	0	3	7	1	18	1	39	64	78	66	96	175	283	237	35	81			
6	10	18	49	52	51	3	4	2	3	7	1	4	3	0	0	1	0	2	5	0	13	0	29	40	48	44	64	121	195	163	24			
7	7	3	6	10	20	8	0	1	0	1	1	0	2	2	0	0	0	0	2	4	0	9	0	17	21	27	25	38	70	119	99			
8+	3	3	2	2	4	2	3	1	0	0	0	0	0	2	3	2	1	1	1	2	4	3	8	5	10	17	24	27	37	62	108			



But it Will be specially important in the projections for catch advice

Are ecological-technical interactions needed in the general model or are they better accomplished outside the general model?

- Stock assessment model
  - Too slow and complex
  - Small changes in some parameters can involve big changes in the assessment
  - Not operational in stock assessment process time-frame
- Support for single species stock assessment
  - Use of natural mortality estimates from multispecies models : North sea Stocks, Barents sea cod and haddock…
  - Consumption estimates by cod on Iceland and Barents Sea capelin
  - CCAMLR: estimate krill needed for predators
- The need of considering trophic interaction will increase as the state of predator stocks improve.
- Ideally being the same modelling framework than the one used for stock assessment with the same sources of information, but only adding the trophic interactions and the diet composition data needed
- General model should have capacity to model trophic interactions

Are ecological-technical interactions needed in the general model or are they better accomplished outside the general model?

- Application of MICE with multispecies interactions
  - Simulation model (OM within MSE)
    - When trophic interactions are clear drivers in the Dynamic and productivity of a stock
    - Real potential to account for the most important ecological aspects on MSE
    - General model including trophic interactions
    - There is no currently a multispecies model with capacity to do all that the general model that is intended here would have

Are ecological-technical interactions needed in the general model or are they better accomplished outside the general model?

- What features are needed?
  - Consumption model by length and time step
  - Prey-Predator suitability functions
- Major difficulties?
  - Data on diet composition
  - Managers
- What Research is needed?
  - Identification of the real need of multispecies interactions
  - Consumption estimates
  - Diet composition
  - Prey preference
  - Prey-predator length relationship

Multispecies modelling: estimation of reference points and assessment of joint HCRs that take into consideration ecological interactions

CAPAM workshop 2019

EU SC05 project:
"Multispecies Fisheries Assessment for NAFO"

Alfonso Pérez-Rodríguez
Institute of Marine Research
Department of Demersal Fish
Bergen, Norway

European Maritime and Fisheries Fund
Framework Programme UE EMFF/2016/008

European Commission

WAGENINGEN UNIVERSITY & RESEARCH

HAVFORSKNINGSINSTITUTTET INSTITUTE OF MARINE RESEARCH

European Commission Joint Research Centre

INSTITUTO ESPAÑOL DE OCEANOGRAFÍA

Cefas

azti tecnalia

ipma instituto português do mar e da atmosfera

MRAG