Bio-economic Impact assessment of the MAP in the Bay of Biscay French demersal fisheries

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Introduction

Simulations of the impact of the multi-annual management plan on the French demersal fleets operating in the Bay of Biscay were undertaken with the bio-economic simulation tool IAM. Biologic dynamic of Bay of Biscay sole and Northern hake were included and a detailed representation of the French fleets operating in the demersal fisheries in the Bay of Biscay was proposed. This document provides a description of the French fleets operating in the Bay of Biscay, a description of the IAM model, the settings, the assumptions and the scenarios tested and an analysis of the results obtained. Part of the description and results were obtained under a project funded by the French DPMA under the article 332 of the IFREMER-DPMA Convention.

Summary and major issues

- The impacts of the 3 scenarios (baseline, Fup, Flow) are assessed with IAM for the French demersal fleets in the Bay of Biscay under a number of assumptions and limits which include:
    - The SWW MAP in the Bay of Biscay only concerns sole and hake as other stocks are DLS, constraints on quotas are not explicitly included
    - Joint productions and correlations between species are modeled at fleet-métier levels and reconciliation is made at this level. By allocating effort differently among métier, area and season fishermen could adjust, to a certain extent, the percentage of species in their catches and thus better reconcile the objectives of the management plan. It can thus be expected that choke effects will not be as important as assessed in the current simulations. Besides, adjustment of effort is assumed to be uniform across fleet and métier whereas management could decide to constraint fleets differently.
    - Adjustment of fishing effort is only carried out by changing the total annual fishing duration by fleet/metier. No reallocation of effort on other fisheries and/or adjustment of the fishing capacities (in number of vessels) have been tested. Economic impacts assessed and presented in this report are expected to be limited by behaviors of effort reallocation according to opportunities and by capacity adjustment
    - An envelope approach is adopted for this IA and scenarios tested enables to assess potential impacts for fleets under assumptions and to test the capacities to reconcile objectives of F targets for several species but they do not enable to test coherence of ranges and the existence of a viable set of fishing possibilities. Viability approaches are interesting and innovative approaches that could be appropriate to MSY ranges stakes and as a framework for the operational implementation of the economic, social and environmental viability constraints.
- Impact assessment of management plans defined for stocks at regional scales requires as a first step to identify vessels impacted ie to identify subsets of vessels by DCF fleet which operates on stocks and/or region managed through MAP and which might be impacted by the MAP implementation;
- Main issues for MAP are the reconciliation of fishing opportunities according to joint productions that occur at the level of fleet-métier-area-season thus advocating for a fisheries based management.
- Slight choke effects due to sole occur in the fishery for mixed fleets.
- Results show that Flow scenario endanger short term economic viability of most of the fleets (except nephrops specialized bottom trawlers and hake longliners) during transition phases while economic short term viability is not endangered in other scenarios.
- Simulations show that mixed bottom trawlers would be the most impacted fleets by the MAP according to assumptions and that mixed and sole netters would also be negatively impacted in particular in scenario Flow while hake gillnetters and longliners and nephrops bottom trawlers would benefit from the MAP.

- Most impacted fleets identified by the IA depend on assumptions on joint production and on possible effort reallocation. Fleets behaviors and management are expected to be able to limit (to a certain extent) negative impact assessed all things being equal (adapt techniques, effort allocation, capacities, etc…).
- Differences in impacted fleets according to scenarios, depend mainly on:
    - métiers by fleet, reconciliation process and choke effects assuming no possible reallocation of effort
    - Dependence and contribution to the different species managed and ability to benefit from stocks recoveries.

1. Description of the French demersal fisheries in the Bay of Biscay

1.1. Fleets characteristics

More than 200 species are caught in the Bay of Biscay with 20 species contributing to 80% of the landings however (Chaloupe ANR project). Main species in value are sole, nephrops, hake, monkfish or seabass. Bay of Biscay concentrates important mixed demersal French and Spanish fisheries of trawlers, netters and longliners with high technical interactions between fleets through species.

In 2013, 792 French vessels operated in the Bay of Biscay demersal fisheries. It represented around 25% of the total French vessels operating in Atlantic and 49% of the French vessels operating in the Bay of Biscay. The bay of Biscay French demersal fisheries total gross revenue was 249 million euros in 2013 and total direct employment was 2256 fishermen.

Main species caught by French vessels in value in the demersal fisheries in the Bay of Biscay are Common sole (17%), Nephrops (10%), European hake (10%), monkfishes (9%), Common cuttlefish (4%) and Sea Bass (4%) (in terms of percentage of the total gross revenue for those fleets).

Two main fleets of bottom trawlers and netters operate in these fisheries among which several strategies and specializations are observed. A fleet typology was developed together with stakeholders in the framework of the partnership bio-economic working group (PBEWG) and the European GEPETO project to provide a more detailed approach of fleets' situation, strategies and potential impact of management plans (Figure 1). 21 fleets were considered in the analysis (see table 1). These fleets are subsets of DCF fleet segments. Hereafter, Sole gillnetters, mixed gillnetters, Nephrops trawlers, Mixed dermersal and Mixed dermersal coastal trawlers, hake longliners and hake gillnetters are considered, each fleet being divided in vessel length (VL) categories. 3 fleets can be considered as small scale fleets (SSF) according to EC definition (Vessels <12m using passive gears exclusively). These SSF represent 38% of the vessels number, most of them being Sole gillnetters.

Figure 1 : Typology of the french demersal fisheries in the Bay of Biscay

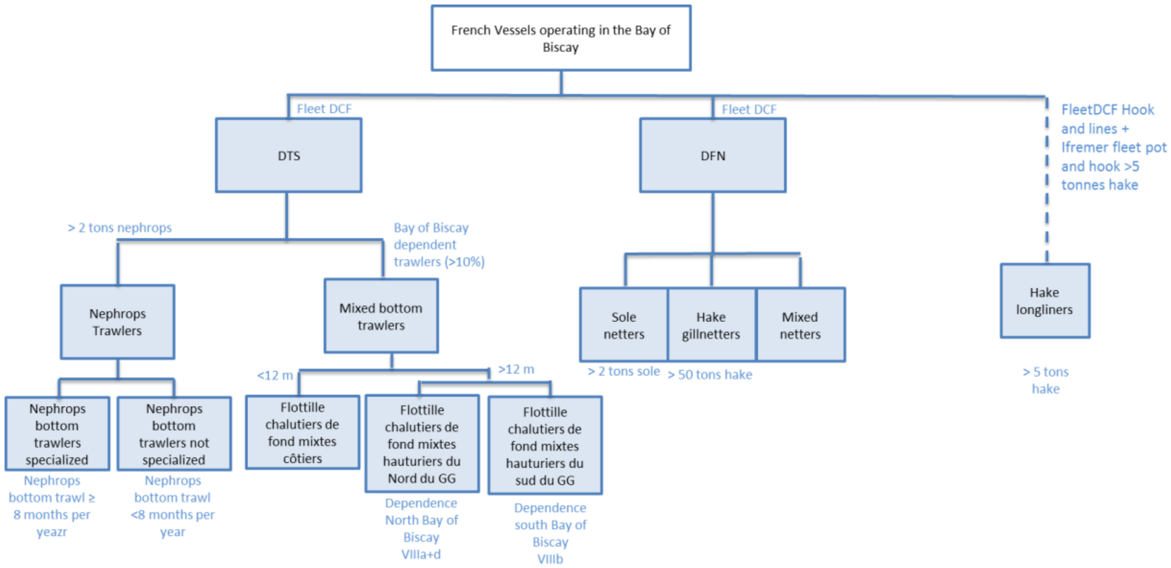


Table 1 provides information by fleet on the number of vessels, employment, effort, dependence to species in terms of % of the value of landings and total value of landings.

NB: a fleet of large hake longliners also contribute to a non-negligible part of the fishing mortality on hake by French fleets in the Bay of Biscay, however, it was not possible to include this fleet explicitly in the model due to absence of economic data for the parameterization of this fleet. This fleet counts 7 vessels in 2013 and catches around 900 tons of hake.

Main fleet segments in terms of vessels are mixed bottom trawlers (210 vessels) and mixed netters (263 vessels). Nephrops trawlers account for around 150 vessels and sole netters for around 130 vessels. Hake specialized fleets (longliners and gillnetters) only account for around 30 vessels but concentrates a large part of the french landings.

The main fleets in terms of gross revenue are the Nephrops trawlers (specialized) VL1224 (12% of the total gross revenue of French demersal fleets in the Bay of Biscay), the Hake gillnetters VL1840 (12%), the Mixed demersal trawlers North Bay Biscay_VL1824 (10%) and the Sole gillnetters_VL1218 (10%).

The most dependent fleets in terms of share of the gross revenue represented by hake and sole are the specialized fleets on either hake (longliners and gillnetters) or sole (sole netters).

Table 1: Characteristics by fleet - Sources: IFREMER/Fisheries Information System/ DPMA - 2013

French demersal Bay of Biscay Fleets	Lenght class	Vessels	Crew size	Crew size (% french BoB demersal fisheries	Dep hake (% VL)	Dep sole (%VL)	Dep sole+hake (%VL)	Dep species modelled (%VL)	Total Value of landings VL (Millions euros)	Days at sea
Hake gillnetters	VL1840	21	252	11%	41%	0%	41%	45%	31,1	4967
Hake longliners	VL0010	7	13	1%	73%	0%	73%	94%	0,8	819
	VL1012	4	11	0%	58%	0%	58%	70%	1,0	715
Mixed coastal bottom trawlers	VL0010	56	79	4%	1%	26%	27%	53%	4,7	6340
	VL1012	90	203	9%	3%	12%	14%	61%	18,8	13827
Mixed bottom trawlers North Bay Biscay	VL1218	13	44	2%	2%	5%	7%	73%	5,8	2579
	VL1824	32	142	6%	1%	1%	2%	37%	26,1	7346
Mixed bottom trawlers South Bay Biscay	VL1218	12	41	2%	5%	12%	17%	72%	5,9	2564
	VL1824	7	36	2%	3%	3%	6%	51%	5,1	1545
Mixed netters	VL0010	220	286	13%	1%	9%	10%	41%	11,5	21140
	VL1018	39	118	5%	3%	2%	6%	41%	8,6	5454
	VL1840	4	25	1%	2%	0%	2%	90%	2,9	728
Nephrops bottom trawlers (specialized)	VL0012	25	57	3%	6%	11%	17%	90%	6,0	4308
	VL1224	75	243	11%	6%	9%	14%	91%	31,2	15788
Nephrops bottom trawlers (unspecialized)	VL0012	4	9	0%	3%	6%	9%	59%	0,8	601
	VL1218	35	119	5%	6%	14%	20%	82%	19,4	8627
	VL1824	10	47	2%	3%	14%	17%	80%	8,9	2451
Sole netters	VL0010	18	40	2%	3%	38%	41%	65%	2,9	2285
	VL1012	50	161	7%	4%	51%	55%	74%	14,0	8336
	VL1218	42	198	9%	5%	53%	58%	76%	26,1	9967
	VL1824	21	133	6%	17%	52%	69%	84%	17,1	4866
Total		**785**	**2256**	**100%**	**10%**	**18%**	**27%**	**66%**	**249**	**125253**
				>5%			>50%	>50%		

DCF Segmentation

Impact assessment of management plans defined for stocks at regional scales (western waters, north sea, etc…) requires as a first step to identify vessels impacted ie to identify a subset of vessels by DCF fleet which operates on stocks and/or region managed through MAP and which might be impacted by the MAP implementation.

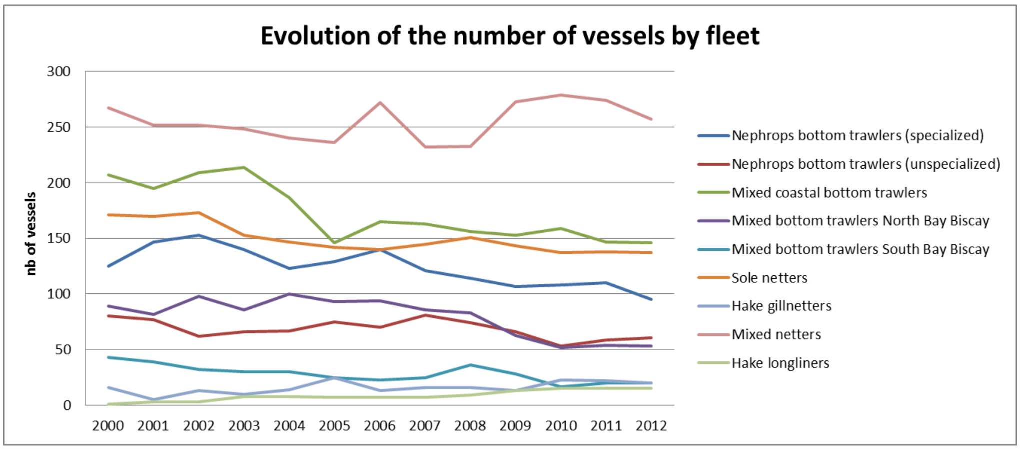
Existing DCF aggregation levels thus aggregate vessels operating in various areas and targeting different stocks that can be managed under different MAP. An impact assessment conducted at this level of aggregation does not enable to highlight the stakes. Example of the French DFN 12-18 m illustrates the consequences and limits of impact assessment conducted at aggregated levels: French DFN 12-18 m thus aggregates vessels operating in different area in Western Atlantic in particular in the Bay of Biscay and in the Channel. The DCF segment aggregates vessels with different behaviors and strategies. Dependency to particular stocks calculated for these aggregated fleets thus average dependency of vessels that can be very different and do not highlight the stakes in a number of cases. Dependency to sole of the Bay of Biscay (in percentage of the gross revenue) is for example of 20% for the DFN 12-18 m while it can be over 50% for subset of the DFN fleet that operates in the Bay of Biscay.

DCF transversal variables of effort and landings exist in France at disaggregated levels (vessel level) and enable to select those subsets and identify and characterize probable impacted vessels.

Methodology adopted in this work is based on a first step of selection of the subset of vessels by fleet operating in the area under MAP.

Among DCF fleets, different strategies have been identified with stakeholders to create a typology that reflects diversity of behaviours observed and enable to identify the main segments that might be impacted by the MAP.

Figure 2: Evolution of the number of vessels by fleet - Sources: IFREMER/Fisheries Information System/ DPMA - 2013

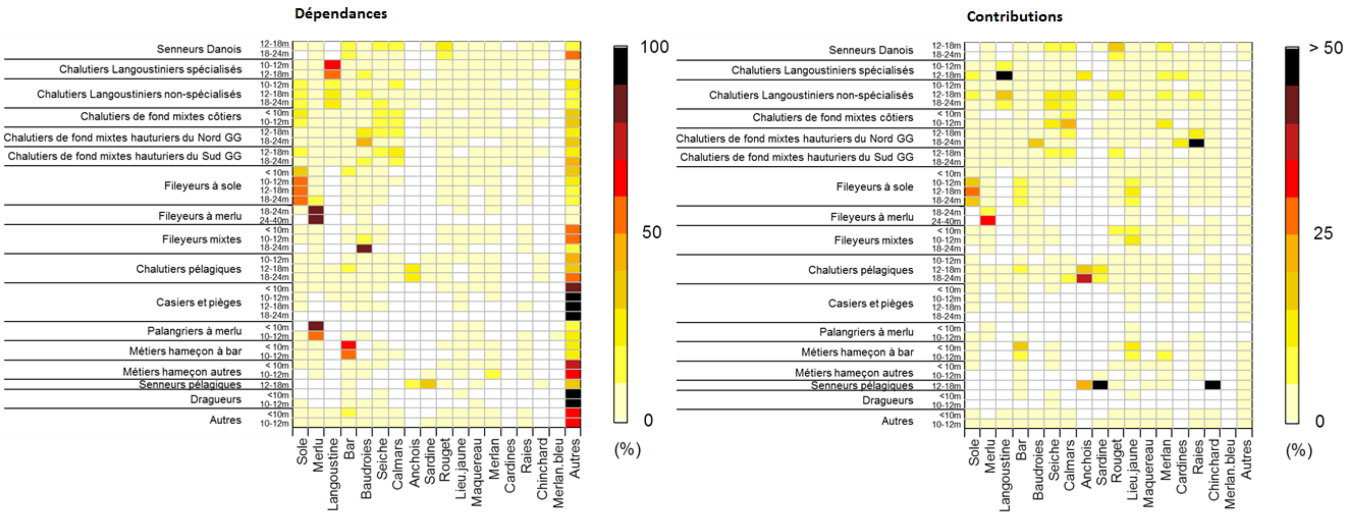


Evolution of the number of vessels show a tendency to decrease for bottom trawlers (due to decommissioning schemes, exit from fisheries and fleet dynamic of reallocation of effort towards other fisheries) while the number of vessels have remained relatively stable in netters fleets. Hake longliners are increasing for several years.

1.2. Contribution and dependence of fleets

Contribution of french fleets operating in the Bay of Biscay to the french landings on the stock and their dependence in terms of percentage of the gross revenue by species are represented in the figure 2 and highlight technical interactions between fleets through species caught by different fleets and mixed strategies and provide information on potential impacted fleets.

Figure 3: Description of interactions between fleets - Contribution of french fleets of the Bay of Biscay to the french landings by stock and dependence of the fleets to the different main species – sources: IFREMER/Fisheries Information System/ DPMA - 2012



Analyses of these matrix of contribution show that sole netters over 10 meters and nephrops trawlers over 12 meters are the main contributors to the sole fishing mortality while French Hake gillnetters are the main French contributors to the hake fishing mortality (contribution of French demersal fleets operating in the Bay of Biscay only represent less than 15% of the fishing mortality on hake however). Dependent fleets to sole and hake are sole netters and hake longliners and gillnetters and to a lesser extent, non-specialized nephrops bottom trawlers and small mixed bottom trawlers. Other fleets (nephrops trawlers, mixed bottom trawlers and mixed netters) can however be dependent on a mix of demersal species such as nephrops, or monkfish that could be also affected by MAP.

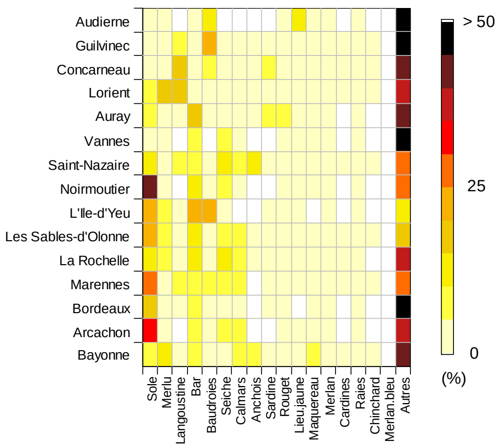
1.3. Dependence, employment and territorial impacts

Analysis of the dependence to sole and hake by fleet and relative importance of employment by fleet highlight that most probable impacted fleets in terms of employment would be sole and hake netters. However, important impacts on mixed fleets are also to be expected due to joint production and choke effects.

Table 2 : Economic dependence to the main species for the selected fleets (% of gross revenue 2013) Sources: IFREMER - IFREMER/Fisheries Information System/ DPMA - 2013

Fleets	ANE	BSS	CTC	HKE	HOM	LEZ	MAC	MNZ	MUR	NEP	PIL	POL	RAJ	SOL	SQZ	WHB	WHG	OTHER
Hake gillnetters_VL1840	0%	0%	0%	41%	0%	0%	0%	3%	0%	0%	0%	0%	0%	0%	0%	0%	0%	55%
Hake longliners_VL0010	0%	7%	0%	73%	0%	0%	13%	0%	1%	0%	0%	1%	0%	0%	0%	0%	0%	6%
Hake longliners_VL1012	0%	6%	0%	58%	0%	0%	1%	3%	0%	0%	0%	2%	0%	0%	0%	0%	0%	30%
Mixed coastal bottom trawlers_VL0010	0%	3%	12%	1%	0%	0%	1%	0%	3%	0%	0%	0%	0%	26%	6%	0%	1%	47%
Mixed coastal bottom trawlers_VL1012	0%	5%	19%	3%	0%	0%	4%	1%	2%	1%	1%	0%	0%	12%	9%	0%	2%	39%
Mixed bottom trawlers North Bay Biscay_VL1218	0%	3%	12%	2%	0%	2%	5%	25%	2%	0%	3%	3%	3%	5%	5%	0%	2%	27%
Mixed bottom trawlers North Bay Biscay_VL1824	0%	0%	1%	1%	0%	3%	0%	26%	0%	0%	0%	0%	4%	1%	1%	0%	0%	63%
Mixed bottom trawlers South Bay Biscay_VL1218	0%	5%	13%	5%	0%	1%	1%	10%	7%	1%	0%	0%	1%	12%	16%	0%	1%	28%
Mixed bottom trawlers South Bay Biscay_VL1824	0%	6%	3%	3%	0%	2%	3%	16%	4%	1%	0%	0%	0%	3%	10%	0%	0%	49%
Mixed netters_VL0010	0%	12%	4%	1%	0%	0%	1%	2%	8%	0%	0%	3%	1%	9%	0%	0%	1%	59%
Mixed netters_VL1018	0%	8%	1%	3%	0%	0%	0%	9%	3%	0%	0%	10%	2%	2%	0%	0%	1%	59%
Mixed netters_VL1840	0%	0%	0%	2%	0%	0%	0%	82%	0%	0%	0%	5%	1%	0%	0%	0%	0%	10%
Nephrops bottom trawlers (specialized)_VL0012	0%	2%	2%	6%	0%	0%	0%	5%	1%	58%	0%	0%	0%	11%	3%	0%	1%	10%
Nephrops bottom trawlers (specialized)_VL1224	2%	1%	1%	6%	0%	3%	0%	12%	1%	55%	0%	0%	1%	9%	0%	0%	1%	9%
Nephrops bottom trawlers (unspecialized)_VL0012	0%	6%	4%	3%	0%	0%	2%	1%	2%	26%	0%	0%	0%	6%	6%	0%	2%	41%
Nephrops bottom trawlers (unspecialized)_VL1218	1%	4%	9%	6%	0%	2%	0%	15%	3%	19%	0%	1%	1%	14%	7%	0%	1%	18%
Nephrops bottom trawlers (unspecialized)_VL1824	2%	3%	12%	3%	0%	1%	0%	11%	3%	22%	0%	2%	1%	14%	5%	0%	1%	20%
Sole netters_VL0010	0%	12%	1%	3%	0%	0%	1%	1%	2%	0%	0%	3%	1%	38%	0%	0%	1%	35%
Sole netters_VL1012	0%	9%	2%	4%	0%	0%	0%	3%	2%	0%	0%	2%	0%	51%	0%	0%	1%	26%
Sole netters_VL1218	0%	8%	2%	5%	0%	0%	0%	4%	1%	0%	0%	2%	0%	53%	0%	0%	1%	24%
Sole netters_VL1824	0%	7%	1%	17%	0%	0%	0%	4%	1%	0%	0%	1%	0%	52%	0%	0%	0%	16%

Figure 4: Dependence of district to species in terms of value of landings by species over the total value of landings by district (French landings excluding > 40 m) - Sources: IFREMER/Fisheries Information System/ DPMA - 2012



Main districts dependent for sole are Arcachon, Marennes, Noirmoutier, and Yeu and Sables d'Olonne and Lorient for hake. Territorial Impacts thus may occur for these districts in the context of a MAP. Other harbours, less dependent on sole and hake but that have high dependency to the mix of demersal species caught together with sole and hake, could also be impacted.

1.4. Technical interactions and joint productions

The Bay of Biscay demersal fisheries are complex mixed fisheries with high level of technical interactions between fleets through species caught by different fleets and joint productions. Joint productions occur at the trip and métier level for a given season and area. Estimation of production functions and joint production thus requires disaggregated data. At the year level, mixed production of fleets observed can result from practicing different métiers along the year and in different area.

Analyses of the landings by fleet highlight the joint productions existing at this level.

Table 3 : Total landings per species or group of species for the selected fleets (in tons 2013) - Sources: IFREMER - IFREMER/Fisheries Information System/ DPMA – 2013

Fleets	ANE	BSS	CTC	HKE	HOM	LEZ	MAC	MNZ	MUR	NEP	PIL	POL	RAJ	SOL	SQZ	WHB	WHG	OTHER
Hake gillnetters_VL1840	0	6	0	5725	0	7	0	252	1	0	0	12	3	0	0	0	4	7455
Hake longliners_VL0010	0	4	0	116	1	0	63	0	0	0	0	1	0	0	0	0	0	10
Hake longliners_VL1012	0	4	0	117	1	0	7	6	0	0	0	3	0	0	0	1	0	36
Mixed coastal demersal trawlers_VL0010	0	11	158	23	3	0	24	4	9	0	0	1	3	83	37	0	21	391
Mixed coastal demersal trawlers_VL1012	0	83	921	230	40	4	421	62	30	18	316	14	23	174	244	1	262	2210
Mixed demersal trawlers North Bay Biscay_VL1218	0	14	203	46	2	45	222	345	16	2	130	46	93	26	41	0	58	441
Mixed demersal trawlers North Bay Biscay_VL1824	55	5	96	172	2	271	3	1528	15	0	0	30	499	11	30	0	4	5247
Mixed demersal trawlers South Bay Biscay_VL1218	4	37	221	137	11	14	42	162	50	4	0	1	17	70	132	0	20	529
Mixed demersal trawlers South Bay Biscay_VL1824	0	33	48	58	4	27	98	213	30	2	0	2	9	14	64	0	14	939
Mixed gillnetters_VL0010	0	111	171	41	6	0	52	54	61	0	0	94	30	67	0	0	46	1309
Mixed gillnetters_VL1018	0	65	41	117	5	0	15	201	17	0	0	241	64	17	0	0	23	1223
Mixed gillnetters_VL1840	0	0	0	16	0	0	0	566	0	0	0	39	12	0	0	0	0	39
Nephrops trawlers (specialized)_VL0012	0	10	37	193	6	10	13	68	9	309	0	3	6	60	26	0	25	272
Nephrops trawlers (specialized)_VL1224	375	29	148	924	52	252	48	887	28	1476	48	23	71	230	27	0	98	1517
Nephrops trawlers (unspecialized)_VL0012	0	4	9	15	2	0	10	3	1	18	3	0	1	4	6	0	7	107
Nephrops trawlers (unspecialized)_VL1218	89	79	553	507	32	148	43	699	70	343	2	42	120	260	207	0	105	1144
Nephrops trawlers (unspecialized)_VL1824	62	31	348	150	47	29	36	231	29	167	0	45	57	109	77	0	46	636
Sole gillnetters_VL0010	0	36	16	47	2	0	18	8	5	0	0	27	7	78	0	0	18	304
Sole gillnetters_VL1012	0	165	89	141	10	0	28	96	20	0	1	79	18	620	2	0	63	915
Sole gillnetters_VL1218	0	273	123	496	7	1	6	270	33	0	0	143	47	1265	0	0	93	1413
Sole gillnetters_VL1824	0	149	81	1204	2	1	3	151	17	0	0	73	45	854	0	0	31	611
Total	586	1147	3262	10475	237	808	1152	5806	441	2341	502	921	1124	3944	891	2	939	26749

As expected, data highlight that trawlers have more multi-species catches than netters or longliners with as a consequence less ability to reconcile catches.

Landings by fleet show that fleets operating on sole also catch hake but in different proportions according to fleets: For Sole gillnetters VL1824, hake represents 11% of their total landings (17% of their total value) while it represents 1% (4%) and 4% (5% in value) for Sole gillnetters VL1012 and VL1218 respectively. For Nephrops trawlers (specialized) VL1224, Nephrops is the first species (55% in value) but Hake or Sole appears to be significant level in the landings

For specialized fleets on hake (hake longliners and gillnetters), sole catches are not observed. Those fleets don't operate on the distribution area for sole which is more coastal.

Analyses of landings by fleet-métier enable to precise correlations between species and show in particular that sole landings by netters are due to trammelnet métier for sole while catches of hake by the same fleets are due to gillnet métier. There is thus ability for these fleets to reconcile both objectives while hake and sole (and other species) are caught by same bottom trawlers métiers. Proportion of species varies however according to main strategies of bottom trawling (demersal trawl cephalopods, nephrops, sole or anglerfish) which also correspond to different spatio-temporal allocation of the effort.

Table 4 : Hake landings per fleet and métier (tons 2013) - Sources: IFREMER - IFREMER/Fisheries Information System/ DPMA - 2013

Fleets	Demersal trawl Anglerfish	Demersal trawl Cephalopods	Demersal trawl Nephrops	Demersal trawl Other species	Demersal trawl Sole	Gillnet Hake	Gillnet Other species	Gillnet Sole	Longline Hake	Longline Other species	Other	Pelagic trawl Other species	Total général	Percentage
Hake gillnetters_VL1840	0	0	0	0	0	5639	5	0	0	0	80	0	5725	55%
Hake longliners_VL0010	0	0	0	0	0	2	0	0	84	0	30	0	116	1%
Hake longliners_VL1012	0	0	0	0	0	0	0	0	107	2	7	0	117	1%
Mixed coastal bottom trawlers_VL0010	0	4	0	7	8	0	0	0	0	0	4	0	23	0%
Mixed coastal bottom trawlers_VL1012	4	45	8	116	30	0	0	0	0	0	23	4	230	2%
Mixed bottom trawlers North Bay Biscay_VL1218	9	5	0	28	2	0	0	0	0	0	1	0	46	0%
Mixed bottom trawlers North Bay Biscay_VL1824	67	2	0	102	0	0	0	0	0	0	1	0	172	2%
Mixed bottom trawlers South Bay Biscay_VL1218	28	20	1	19	14	0	0	0	0	0	5	49	137	1%
Mixed bottom trawlers South Bay Biscay_VL1824	32	11	1	11	2	0	0	0	0	0	2	0	58	1%
Mixed netters_VL1018	0	0	0	0	0	56	46	1	3	0	11	0	117	1%
Mixed netters_VL1840	0	0	0	0	0	3	13	0	0	0	0	0	16	0%
Nephrops bottom trawlers (specialized)_VL0012	4	3	152	9	11	0	0	0	0	0	14	0	193	2%
Nephrops bottom trawlers (specialized)_VL1224	80	1	665	94	19	0	0	0	0	0	44	20	924	9%
Nephrops bottom trawlers (unspecialized)_VL00	0	1	9	3	1	0	0	0	0	0	2	0	15	0%
Nephrops bottom trawlers (unspecialized)_VL12	88	42	187	56	100	0	0	0	0	0	25	9	507	5%
Nephrops bottom trawlers (unspecialized)_VL18	13	11	101	5	14	0	0	0	0	0	6	1	150	1%
Sole netters_VL0010	0	0	0	0	0	45	23	4	0	0	16	0	88	1%
Sole netters_VL1012	0	0	0	0	0	15	26	31	57	0	11	0	141	1%
Sole netters_VL1218	0	0	0	0	0	293	46	98	0	1	59	0	496	5%
Sole netters_VL1824	0	0	0	0	0	1017	17	37	0	0	133	0	1204	11%
Total	326	144	1125	449	202	7071	176	171	251	3	472	84	10474	100%
Percentage	3%	1%	11%	4%	2%	68%	2%	2%	2%	0%	5%	1%	100%	

Most of the hake landings come from gillnets (62%) and longline (10%). Demersal and pelagic trawl provide the remaining landings for which hake discards are significant. The most important fleet contributing to landings are the hake gillnetters VL1840 (50% total landings), followed by the sole gillnetters VL1824 (11%) and the Nephrops trawlers (specialized) VL1224 (8%).

Table 5 : Sole landings per fleet and métier (tons 2013) - Sources: IFREMER - IFREMER/Fisheries Information System/ DPMA - 2013

Fleets	Demersal trawl Anglerfish	Demersal trawl Cephalopods	Demersal trawl Nephrops	Demersal trawl Other species	Demersal trawl Sole	Gillnet Hake	Gillnet Other species	Gillnet Sole	Longline Hake	Longline Other species	Other	Pelagic trawl Other species	Total	Percentage
Hake gillnetters_VL1840	0	0	0	0	0	0	0	0	0	0	0	0	0	0%
Hake longliners_VL0010	0	0	0	0	0	0	0	0	0	0	0	0	0	0%
Hake longliners_VL1012	0	0	0	0	0	0	0	0	0	0	0	0	0	0%
Mixed coastal bottom trawlers_VL0010	0	4	0	3	63	0	0	0	0	0	12	0	83	2%
Mixed coastal bottom trawlers_VL1012	1	38	4	19	92	0	0	0	0	0	19	0	174	4%
Mixed bottom trawlers North Bay Biscay_VL1218	2	8	0	3	13	0	0	0	0	0	1	0	26	1%
Mixed bottom trawlers North Bay Biscay_VL1824	5	4	0	1	1	0	0	0	0	0	0	0	11	0%
Mixed bottom trawlers South Bay Biscay_VL1218	10	19	1	12	23	0	0	0	0	0	4	0	70	2%
Mixed bottom trawlers South Bay Biscay_VL1824	5	3	0	3	2	0	0	0	0	0	1	0	14	0%
Mixed netters_VL1018	0	0	0	0	0	0	3	10	0	0	3	0	17	0%
Mixed netters_VL1840	0	0	0	0	0	0	0	0	0	0	0	0	0	0%
Nephrops bottom trawlers (specialized)_VL0012	1	3	31	2	19	0	0	0	0	0	5	0	60	2%
Nephrops bottom trawlers (specialized)_VL1224	20	4	154	8	32	0	0	0	0	0	13	0	230	6%
Nephrops bottom trawlers (unspecialized)_VL00	0	0	2	1	0	0	0	0	0	0	0	0	4	0%
Nephrops bottom trawlers (unspecialized)_VL12	21	49	49	20	111	0	0	0	0	0	10	1	260	7%
Nephrops bottom trawlers (unspecialized)_VL18	7	25	21	4	46	0	0	0	0	0	4	0	109	3%
Sole netters_VL0010	0	0	0	0	0	0	16	93	0	0	35	0	144	4%
Sole netters_VL1012	0	0	0	0	2	0	23	515	0	0	80	0	620	16%
Sole netters_VL1218	0	0	0	0	0	0	35	1174	0	0	57	0	1265	32%
Sole netters_VL1824	0	0	0	0	0	0	13	794	0	0	48	0	854	22%
Total	73	157	262	76	405	0	91	2585	0	0	292	1	3943	100%
Percentage	2%	4%	7%	2%	10%	0%	2%	66%	0%	0%	7%	0%	100%	

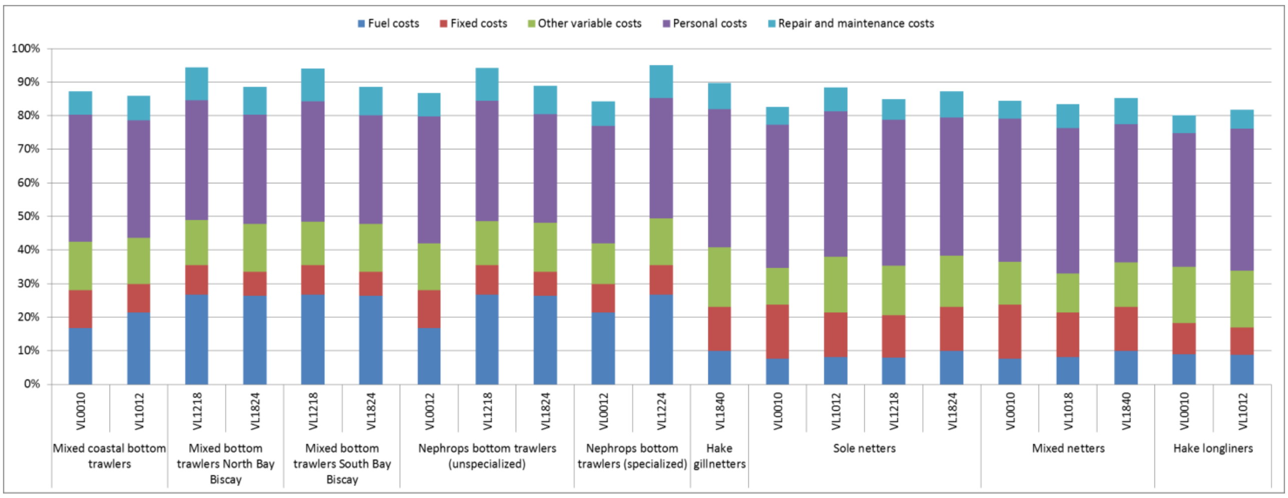
Most of the sole landings come from net gears (73%) and mainly trammel nets targeting sole. Demersal trawlers provide the remaining landings (see discards). The most important fleet contributing to landings are the sole gillnetters VL1218 (32% total landings), VL1824 (22%), VL 10-12 (16%), followed by Nephrops trawlers (unspecialized)_VL1218 (7%) and Nephrops trawlers (specialized)_VL1224 (6%).

1.5. Economic performances of fleets

Cost structure by fleet is represented in the figure 5 and shows relative profitability of the fleets.

Profitability of the different fleets in the bay fo Biscay is between 5% to 10% for the less profitable (bottom trawlers over 12 meters) and 10% to 20% for the most profitable (hake longliners). Structure of costs highlights higher fuel costs for bottom trawlers and higher personal costs for netters.

Figure 5: Cost structure by fleet in 2013 – sources DCF-DPMA 2013



1.6. Fisheries management issues

Different types of fisheries management measures have already been established in the Bay of Biscay (Lagière et al. 2013). These measures could impact the way harvesting capacity change and vessels operate in this area. Conservation measures (TAC, mesh size, area closures, etc) are distinguished from access regulation measures (licence, individual or vessel quotas). These measures apply to species, gears, fleets, and on specific areas.

Conservation measures

The fisheries in the Bay of Biscay are mainly managed through norms or conservation measures imposed by the central administration. Sole, Nephrops, Hake and Monkfish are thus submitted to TAC and quotas system, minimum landing sizes, technical measures (mesh sizes limits and selectivity measures), (EC Reg. No. 850/98 and 1239/98).

Effort reallocation for the different fleets may be restricted by constraints in terms of TAC and national quotas consumption. The following table shows the level of the French quota after exchange in 2013/2014 and their consumption rates for the main species considered. As indicated below, quota consumption was critical for Common Sole and Pollack in 2013 and 2014 and for anchovy in 2004. Quota consumption rate is quite high for monkfishes and megrims (between 80 and 85%) for both years. Horse mackerel consumption rate is quite low (38% and 50%) but should be considered in the case landing obligation applied as this species is discarded by some fleets.

Table 6: French quota after exchange, catches and consumption rate for the main species (species ordered according to decreasing value of landings)- Source : DPMA-FIDES

Year	Species	Area	Adapted Quota	catches	Consumption rate	Year	Species	Area	Adapted Quota	catches	Consumption rate
2013	SOL	8AB.	4120	3879	94%	2014	SOL	8AB.	3724	3716	100%
2013	NEP	8ABDE.	4196	2431	58%	2014	NEP	8ABDE.	4285	2802	65%
2013	HKE	8ABDE.	18839	13634	72%	2014	HKE	8ABDE.	22207	15999	72%
2013	MNZ	8ABDE.	7398	6154	83%	2014	ANF	8ABDE.	8352	6805	81%
2013	POL	8ABDE.	1442	1337	93%	2014	POL	8ABDE.	1405	1384	98%
2013	RAJ	89-C.	1739	261	15%	2014	SRX	89-C.	1498	291	19%
2013	LEZ	8ABDE.	1195	850	71%	2014	LEZ	8ABDE.	1085	920	85%
2013	MAC	2CX14-	16822	13996	83%	2014	MAC	2CX14-	27024	16615	61%
2013	WHG	08.	2405	1939	81%	2014	WHG	08.	2305	1571	68%
2013	ANE	08.	3591	2427	68%	2014	ANE	08.	4479	4245	95%
2013	HOM	2A-14	17012	6462	38%	2014	JAX	2A-14	9167	4583	50%
2013	WHB	1X14	8319	7182	86%	2014	WHB	1X14	19449	11486	59%

Access regulations

Entry to the Common sole fishery has been subject to permit holding since 2008 and licences with *numerous clausus* were implemented for the Nephrops fishery and Sea Bass in 2004 and 2011, respectively. The Anchovy fishery is subject to permit holding. These regulation reduce the capacity of vessels to switch from a fishery to another. Moreover, for common sole and for other EU species, the French quota are shared out into sub-quotas per Producer Organisation (PO) as defined by legal statutes dating from 2006 (JORF, 2006). The distribution allocation between POs is drawn up on a track-record criterion based on the average landings of member producers over the period 2001-2003 (Larabi et al., 2013). POs gradually imposed individual vessel quotas for common sole on their members for two main reasons: to avoid penalties for quota over-fishing, and in response to increasing constraints on quota linked to stock recovery and constant TAC. Vessel quotas also apply for other species like European Hake or Mackerel but it depends on each PO.

As a consequence, vessels effort allocation between the different métiers and fisheries should be considered with attention.

2. Model description IAM

2.1. Development and application

The Impact Assessment bio-economic Model for fisheries management (IAM) has been developed since 2009 in the framework of:

- national projects (Bio-economic partnership working group project funded by the French Directorate of Sea Fisheries and Aquaculture of the French Ministry of Ecology, sustainable development and ecology since 2009[1], ANR ADHOC project (2010-2014) funded by the National Research Agency, National SIAD project)
- European funded projects (SOCIOEC – Socio economic Effects of Management Measures of the future CFP - http://www.socioec.eu/)

The Impact Assessment bio-economic Model for fisheries management (IAM) (Merzéréaud et al., 2011) is an integrated model coupling the biological dynamics of fish stocks with the economic dynamics to perform impact assessment of scenarios. The model has been described and applied in STECF context (STECF, 2011) and in various publications related to the impact assessment of selective scenarios, MSY or MEY target reference points, remuneration system or ITQ and governance scenarios (Raveau et al., 2012, Macher et al., 2013, Guillen et al., 2014, 2015).

2.2. Main characteristics

The model has been developed in R/C++ to allow easy handling, flexibility and performance. The core of the program has thus been coded in C++ and the interface uses R for data handling, for outputs and to produce graphs. The use of two complementary programming languages (R/C++) enables to take advantage of both tools and to offset their disadvantages.

Parameterization is facilitated by the use as input of the outputs of the stock assessment working groups (inputs for short term prediction) and of a limited number of indicators calculated from DCF transversal and economic data at disaggregated levels for the parameterization of production, effort, technical characteristics and profitability by fleet and prices by species. For the French fisheries, this process has been automated by linking the model to the Ifremer databases.

The main characteristics of the model are the following:
The model is multi-species, multi-fleets (or multi-vessel) and multi-metiers.
It is age-structured for stocks dynamic and has an annual or quarterly time step for biological dynamics and an annual time step for fleet dynamics.
It is a stochastic model (recruitment, price…)
The model is structured on a modular basis to allow flexibility in the development. Each module describes a process and works with a set of inputs and a declaration of the outputs. The modular structure enables to add extra functions.

2.3. Modules description

A mortality module splits fishing mortality at age for dynamic species between fleets and métiers according to exploitation pattern by métier and landings proportion.

[1] The Bio-economic partnership working group project aims at gathering together an expert group of fishermen's representatives, French administration and scientists to build methodologies of impact assessment (definition of typology, qualitative and quantitative analyses of fleets dynamics and behaviours, scenarios, options, model development, impact assessment indicators) and provide analyses of the potential advantages and disadvantages of scenarios from a multi-criteria perspective (biological and socio-economic impacts).

The population dynamics module calculates at each time step (quarterly or yearly) the population of each species modeled (accounting for survival of discards) according to scenarios and thus fishing mortality modeled. Fishing mortality of other non-explicitly modeled fleets is aggregated into a Fotherfleets by age and varies according to scenarios.
The catches, landings and discards module calculates productions by fleet-métier and species based on:

- the Baranov equation for stocks with dynamic population models;
- linear relationships between CPUE and effort by métier for other main species with assumption of constant CPUE for those species (other assumptions are possible for CPUE including variable CPUE for short life species or tendency for CPUE).

Discarding behaviours can be modeled and determines the proportion of discards and landings.

Several kinds of market models are possible:

- constant price assumptions per species with various level of aggregation (fleet, fleet and métier, fleet/métier and grade)
- price-quantities relationship
- price-importations/exportations relationship

The economic module calculates economic indicators by fleet or fleet/métier or for the whole fishery including measures of the profit, wages etc.
Various systems of remuneration for crew can be assumed.

Economic dynamics such as fleet dynamics, catchability increase through investment or technical creeping, or short terms behaviors, can be included.
Several assumptions concerning impacts of scenarios on gross revenue are possible, including reallocation of effort assumptions.
Fleet behaviours can either follow historical behaviours under constraints of objectives of F or quotas or behave according to a mix of habits and profit maximisation as described in Marchal et al, 2011.

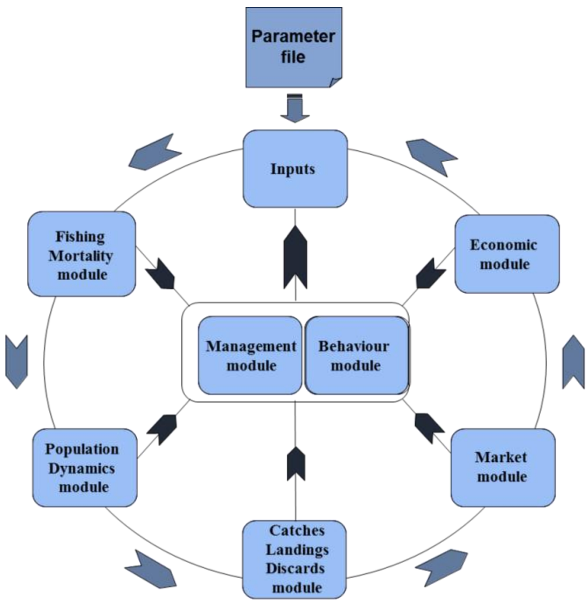


Figure 6: Modular structure of IAM model

The management module enables to adjust variables at each time step. The model can also work as an optimization model.
Classical management scenarios can be implemented such as selectivity, adjustement to TAC or F, variation of the capacities (nb of vessels) or of the fishing effort, ITQ system, etc.

The model can adjust and reconcile effort by fleet and metier to observe objectives of F or TAC on different species under assumptions.
Adjustment of effort by fleet and métier can be uniform for fleet-métier that catch the species considered (scenario close to a conservation of catch shares) or can be weighted according to fishing mortality by fleet and métier for example (more effort to reach management target for fleets with higher impacts on the stocks).

2.4. Reconciliation process

In the case of multi-species F target (F objective for sole and hake for example), reconciliated F is obtained by fleet and métier as the minimum between the effort by fleet and métier such that F hake is reached and the effort by fleet and métier such that F sole is reached (without bounding constraints)

Example:

	Fleet 1	
Métier	Métier 1	Métier 2
Species caught	Sole and hake	Sole
Effort compatible objective	E*fl1,met1 → sole objective E**fl1,met1 → hake objective	E*fl1, met2 → sole objective
Reconciliation	Min(E*;E**)	E*

We thus resolve :
Efl,met such that

- F is reached
- ∃ μ : Efl,met = Efl,met_ini*(1+μ*Wfl,met)

with
Wfl,met = 1 or 0 according to fl,met

When Bpa constraints bound, reconciliation process operates to give priority to these constraints when effort for reconciliated F and effort for targeted minimal SSB are incompatible.

2.5. Outputs

The model provides outputs on transition phases and cost-benefit analyses
The program generates full time series data set and compiles several statistics:

- status of stocks (biomass, spawning biomass, fishing mortality, total catch, risk of Blim or risk of Bpa, F/FMSY…)
- fleet performance (Total Gross Return, Gross Value Added, Total Gross Cash Flow, Profit of the fleet)
- individual performance by fleet (Mean Gross Return, mean Gross Cash Flow, mean Profit)
- total vessel number by fleet
- employment in the fishery
- crew salaries
- producer, consumer and state surplus variation ie rent (net present value)
- Choke effects can be highlighted

3. Application – impact assessment WW MAP

Data sources, dimensions of the model and main assumptions and limits of the application of IAM for the STECF IA of the SW MAP are described in this section.

3.1. Dimensions

For IA of the WW MAP, IAM includes:

- 17 Species (3 species with population dynamics + 13 species + one aggregation of other species with constant CPUE)
- 9 main french demersal fleets * length classes -> 21 fleets subsets of DCF segments mainly Demersal trawlers and netters
- 12 métiers

Among the main demersal species of the Bay of Biscay, a large part of the stocks are DLS. In the simulation carried out for this impact assessment, only the stocks of hake, nephrops and sole are modeled with a full analytical population dynamic model. For the other species, the stock abundance is assumed to be constant. Furthermore, hake and sole are the only species to be constrained as they are the only ones with a full assessment and for which MSY reference points have been defined. It must be noted that other species such as monkfish or *nephrops* are also managed through TAC and can induce choke effects that are not taken into account in the present simulations.

Species, fleets and métier included in the model are summarized in the tables below:

Table 7 : List of species included in the model IAM

Species	Commercial importance	TAC	Potential reallocation species	Discarded species	Special fishing permits and licence	Model	stock status	MSY
Sole	X	X		X	X	Dynamic	Assessed	MSY
Nephrops	X	X		X	X	Dynamic	DLS 3.2	MSY proxy
hake	X	X		X	Fixed Net licence	Dynamic	Assessed	MSY
Sea bass	X		X	X	X	Constant CPUE		
Monkfish	X	X	X	X	Fixed Net licence	Constant CPUE	DLS 3.2	MSY proxy
Seiches	X		X	X		Constant CPUE		
Calmars	X		X			Constant CPUE		
Anchovy	X	X			X	Constant CPUE	Assessed	
Pilchard	X				Seiner licence	Constant CPUE		
Red Mullet	X					Constant CPUE	DLS 5.2	
Pollack	X	X	X	X		Constant CPUE	DLS 5.6	
Mackerel	X	X		X	Seiner licence	Constant CPUE		
Whiting		X	X	X		Constant CPUE	DLS 5.2	
Megrim		X				Constant CPUE	DLS 3.2	MSY proxy
Rays		X				Constant CPUE	DLS 3.2 or 5.2	
Horse Makerel		X		X	Seiner licence	Constant CPUE	Assessed	
Blue whiting		X				Constant CPUE		
Other		(X)				Constant CPUE		

Table 8 : List of fleets included in the model IAM

Fleet	Lenght class
Hake gillnetters	VL1840
Hake longliners	VL0010
	VL1012
Mixed coastal demersal trawlers	VL0010
	VL1012
Mixed demersal trawlers North Bay Biscay	VL1218
	VL1824
Mixed demersal trawlers South Bay Biscay	VL1218
	VL1824
Mixed gillnetters	VL0010
	VL1018
	VL1840
Nephrops trawlers (specialized)	VL0012
	VL1224
Nephrops trawlers (unspecialized)	VL0012
	VL1218
	VL1824
Sole gillnetters	VL0010
	VL1012
	VL1218
	VL1824

Table 9 : List of métiers included in the model IAM

Métiers
Demersal trawl Cephalopods
Demersal trawl Other species
Demersal trawl Anglerfish
Demersal trawl Nephrops
Demersal trawl Sole
Pelagic trawl Other species
Net Other species
Net Hake
Net Sole
Longline Other species
Longline Hake
Other

3.2. Data sources

Table 10 provides information on the input data used for parameterization of IAM and of the sources

Table 10 : Input data and sources

DATA	LEVEL	SOURCE
Stock	Dynamic species	ICES 2013
Production	Fleet /métier/species	IFREMER/FIS/DPMA - SACROIS 2013
Effort	Fleet/métier	IFREMER/FIS/DPMA - SACROIS 2013
Discards	Fleet/métier/dynamic species	ICES 2013
Discards	*Fleet/métier/other species*	*DCF- IFREMER/FIS/DPMA OBSMER 2013*
Economic	Fleet – Fleet/métier	DCF- DPMA 2013 – DCF fleet*bay of Biscay
Market Price	Fleet/métier/grade/dynamic species Fleet/métier/other species	IFREMER/FIS/DPMA - SACROIS 2013
Market price and costs for unwanted catches	species	Literature review + STECF exemption review
Quotas	Species	DPMA/FIDES

3.3. Assumptions and limits

Main assumptions and limits used for the IA application are summarized and discussed in the table below:

Table 11 : Assumptions for simulations with IAM, limits and comments

Variable or process	Assumptions	Limits and comments
Recruitment	Stochastic – hockey-stick - 250 iterations	
F "other fleets" (i.e., foreign fleets and fleets fishing outside the Bay of Biscay)	Adjusted to target	Joint production, potential need for reconciliation and behaviors of the "other fleets" is not modeled which may lead to an **overestimation of F** for those fleets. As seen with the French fleet for which this processes are explicitly modeled, choke species effects and behaviors under constraint may lead to lower F than intended.
CPUE main species	constant	Landings of main other species than hake, sole and nephrops are assumed to increase or decrease proportionally with effort, impact of fleets on stock dynamics of those species is assumed to be negligible and biomass of those stocks to be constant
Prices	Constant prices by fleet-métier-grades	Disaggregation of price by fleet-métier and grades enables to account for the impact of the stock recovery on the structure of the landings by fleet-métier and grades and for price effect due to higher value by grade by métier and fleet

		Price-quantity effects are not taken into account however and can be expected in scenarios where the global supply is changing significantly for species for which landings of the bay of Biscay are a large amount of the total market. While for hake, supply by the Bay of Biscay French fleets does not account for a large part of the market, for sole, bay of Biscay supply is more than a half of the French total consumption and for nephrops; alive nephrops of bay of Biscay is an identified market. Absence of Price-quantity relationship might overestimate losses in the transition period and gains in the middle terms mainly for sole and nephrops dependent fleets.
Economic cost structure	Constant economic cost structure	Assumption of constant economic cost structure provides trends for economic impacts but do not enable to account for behaviors of fleets in terms of investment, adjustment of crew share etc that can limit potential negative economic impacts or have effects on the distribution of impacts between owners and crew according to labor or capital constraints.
Fuel price	Constant fuel price	In scenarios resulting in total effort variations, constant fuel price assumption decrease the difference between the baseline and scenarios
Fleets behaviours	Fleet behaviours follow historical behaviours under constraints and adjustment of effort by fleet and métier is uniform for fleet-métier that catch the species considered Reallocation of effort to other species is assumed not to occur in applications shown in this report	Economic impacts on fleets assumed that effort to match the objectives is uniform for all the fleets while it can be expected that management impose a higher constraint on the larger contributors to fishing mortality and quotas to minimize economic impacts Fleets are assumed to be unable to reallocate effort on other species and métiers, this was discussed in focus groups in SOCIOEC in the case of the sole management plan and data analyses were conducted. Reallocation of effort to other species in the bay of Biscay was shown to be very limited for trawlers and to be possible (even if not so obvious) for netters that could reallocate partly
Discarding behaviours	Constant proportion of discards at age or by species	Do not account for pos
Fleet dynamics	Constant number of vessels by fleet	Fleet dynamics are not included. We assume here that adjustment variable to the management plan is the effort of the fleet and métier. Analysis of tendency shows a slight decrease of trawlers over the last ten years that is partly due to decommissioning schemes; exit from fishing sector and to reallocation of effort to other fisheries. PO’s management of the fishing plan by vessel is also able to create fleet dynamics. However for short term projections constant number of vessels assumption is an acceptable assumption and corresponds (i) to current management operated by PO based on pooling and redistribution of rights between members and (ii) to absence of tool for access regulation and capacity adjustment
Constraints	No explicit TAC constraints in Fup and Flow scenarios	Quotas constraints are not modeled in the system where target are Fup and low objectives for species managed under the MAP (sole and hake) (NB a +/- 15% catch is modeled however in the baseline

		scenario as requested) Landings of MAP species and other main species modeled by constant CPUE cannot exceed quotas due to F constraints not reached, assumptions of initial allocation of effort by métier and absence of potential reallocation of effort For nephrops however, management of hake and sole tends to recover the stock and to increase the landings which might be over the decided TAC
Weighting of impacts on effort by fleet and metier	Uniform over fleets-métier by targeted species	Uniform evolution of effort by fleet and métier is applied by assuming that all the fleet-métier catching the species managed will be impacted in the same way to reach target (this is close to assuming that quota by fleet is reduced in the same proportion for all the fleets with however effects of the various exploitation patterns). Management could however apply different weighting (according to the contribution to total fishing mortality for example) which could potentially reduce socio-economic impacts. Fishermen could also allocate differently their effort between métiers according to constraints. Here also, this could potentially reduce the socioeconomic impacts of the MAP on the fleets.
Remuneration system	Crew share remuneration system	The system of crew share remuneration is the most widespread in fisheries and is thus appropriate in the current simulation. However the landing obligation could lead to increase sorting time of the catch and thus have consequences in terms of labor, crew number and crew remuneration. In the nephrops fishery for example, during the nephrops season, more crew are hired to sort the fish more quickly and guarantee alive nephrops and return to harbor for the auction time, those crew can be employed with a fixed remuneration system. This aspect is to be further analyzed together with landings obligation impacts and holding and sorting constraints
Joint production	Species composition defined at the fleet-métier level	Species composition are defined at fleet-métier level in the parameterization due to the dimensions of the model that is not spatial neither seasonal. Abundance distribution of stocks over season and zones and allocation of effort by season and zone can modify the correlations between species and give fishermen space for reconciling various quota constraints. Entry-exit from the fishery due to economic dynamics of investment/disinvestment and PO management can also modify the interactions.
Landing obligation	Consequences of implementation and exemptions are economic in the model as management is driven by F objectives according to Tor	Landings obligation in the framework of F objectives is here assumed to lead to economic impacts due to landings of unwanted catches (landings and sorting costs). In the case of TAC constraints matching with F, flexibility of LO would lead to increase F compared to objective. It is here assumed that landings match the F objectives and that LO flexibility only decrease economic impacts but do not enable to optimize the TAC use. In coastal mainly daily trips fisheries, holding constraints is assumed to be not

		constraining, sorting constraint would probably bound and could impact either the crew remuneration or the owner surplus according to remuneration system supposed for additional crew. Further analysis of sensitivity of economic results of LO according to remuneration system are under progress

4. Scenarios tested

3 scenarios were tested to analyze the value added of the implementation of MAP, a baseline scenario corresponding to the implementation of the current CFP, a scenario assuming that stocks are fished at Flow and a scenario assuming that stocks are fished at Fup.

Table 12 : Table of reference target (FMSY, Fup and Flow) by species

Species/ref targets	**FMSY**	**Fup**	**Flow**
Sole VIIIab	0.26	0.36	0.17
Northern Hake	0.27	0.37	0.18

Table 13 : Synthesis of the scenarios tested

Scenarios	Scenarios name	Objectives	Constraint
Baseline	Baseline_eff_noflex_alea	Objectives of FMSY for sole and hake from 2016 Uniform reconciliation of objectives by fleet and métier	Catch constraint of +/-15% until 2020 Biomass recovery process in 5 years if SSB<Bpa sole (ref to MP sole) No biomass recovery process for hake as the Bpa of the MP regulation is not updated and thus not used for decision Landings obligation from 2018 without flexibility
Fup	Fup_eff_5years_flex_alea	Baseline until 2017 and then objectives of Fup for sole and hake from 2017 with uniform reconciliation of objectives by fleet and métier	no catch constraint Biomass recovery process in 5 years if SSB<Bpa sole or hake Landings obligation from 2018 with flexibility (de minimis 5%)
Flow	Flow_eff_5years_flex_alea	Baseline until 2017 and then objectives of Flow for sole and hake from 2017 with uniform reconciliation of objectives by fleet and métier	no catch constraint Biomass recovery process in 5 years if SSB<Bpa sole or hake Landings obligation from 2018 with flexibility (de minimis 5%)

3 hockey sticks Stock-Recruitment relationship are assumed for hake, nephrops and sole.

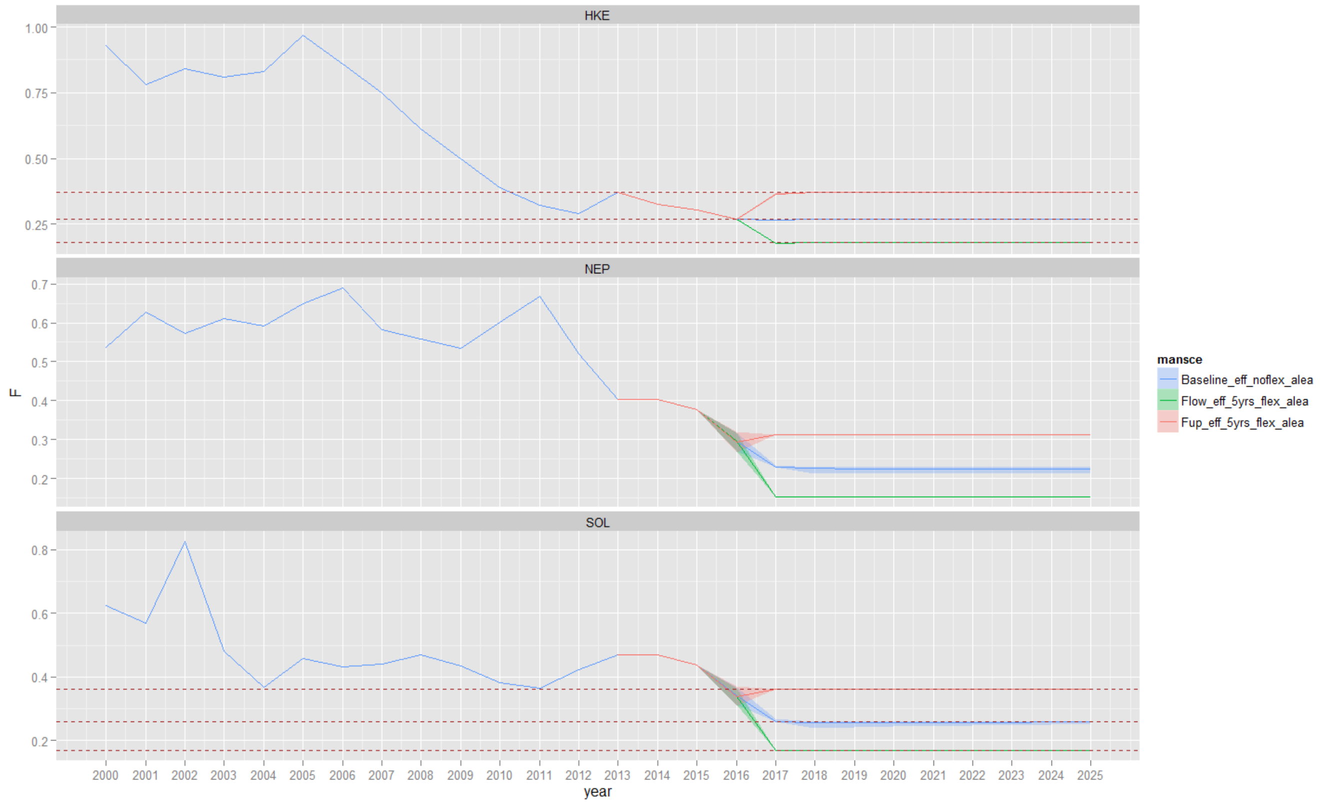
5. Results and discussion

It should be noted that results are obtained under assumptions and thus limits that are summarized and discussed in the table 11 and that should be kept in mind while analyzing results. Main limits and consequences of assumptions on results are reminded and discussed in this section.

5.1. Biological impacts

Evolution of fishing mortality for the 3 scenarios observed in figure 7 shows that F objectives for hake and sole are reached (or almost) for all the scenarios. It highlights that reconciliation of objectives for sole and hake is possible.

Figure 7 : Evolution of Fishing mortality by modeled stock according to scenarios - Outputs IAM



Effort adjustment by fleet and métier thus seems to enable matching of F objectives for sole and hake.

Nephrops is caught together with sole and hake according to input parameterization and thus follow trends for sole and hake. Decrease in F observed for nephrops is to be linked with management objectives for sole and hake, however it should be underlined that correlations between nephrops and sole are not as strong as modeled in this application at the fleet-métier level. Distribution of sole and nephrops landings thus show that landings of both species have low overlap and that there is possibility for fishermen to catch both species almost separately. Nephrops and hake are more joint by the spatial distribution of both species. Those results are linked with the model assumptions on joint productions at fleet-métier levels and should be used cautiously to avoid interpretation and to prevent conclusions that MAP on sole and hake would also manage nephrops.

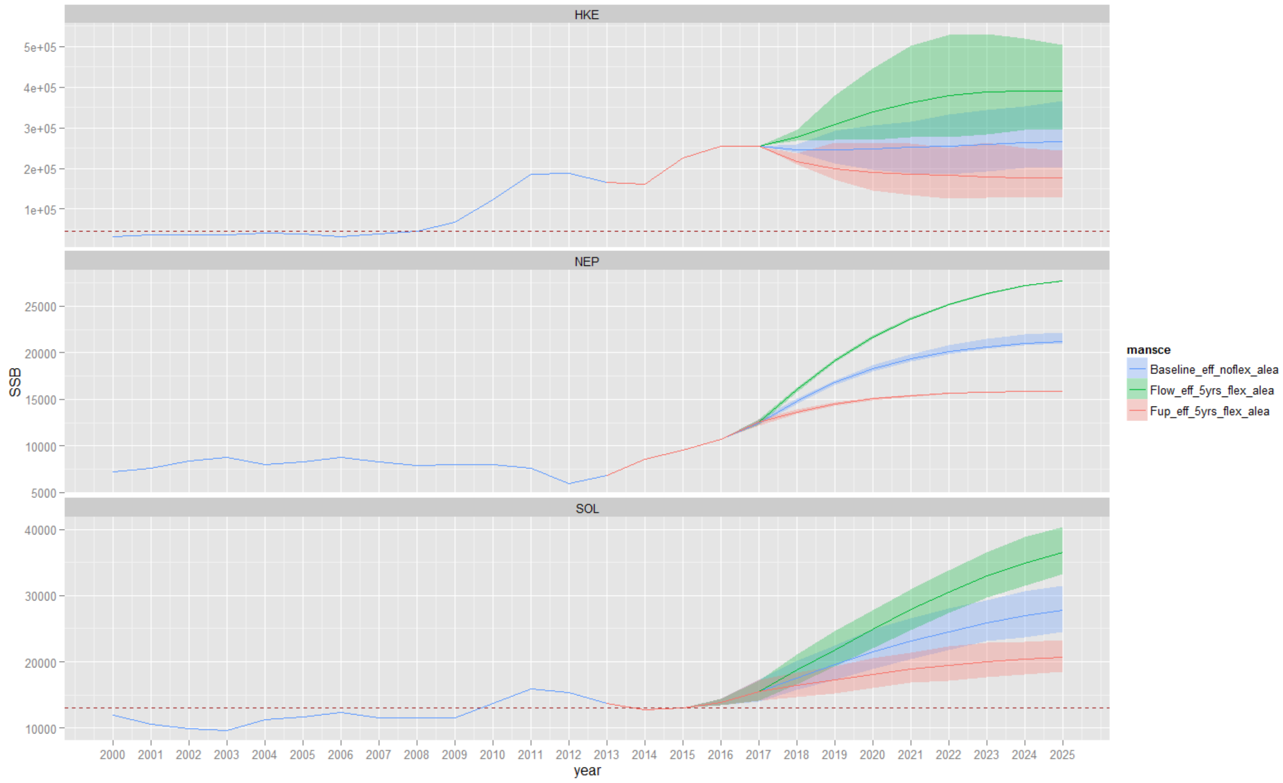
It should be noted that modeled fleets only account for a small part of the fishing mortality on hake and that choke effects for other non-explicitly modeled fleet is not taken into account. In the case of nephrops or sole, modeled fleets account for more than 90% of the total mortality on those stocks.

Variability around F observed is due to catch constraints which depend on recruitment. In the case of hake, no safeguards or constraints operate, in the case of sole, constraints of catch variation operate initially.

Nb In the case of sole, ICES considers that the basis for FMSY may need to be reevaluated and that this revision may be carried out in the short term. This issue is going to be considered during a workshop on Fmsy ranges for western waters stocks scheduled in fall this year.

Definition of safeguards in terms of SSB instead of F makes adjustment of effort to reach targeted SBB depend on recruitments and provides results that are not obvious as effort can increase or decrease to reach the SSB target according to recruitment.

Figure 8 : Evolution of Spawning Stock Biomass by modeled stock according to scenarios - Outputs IAM



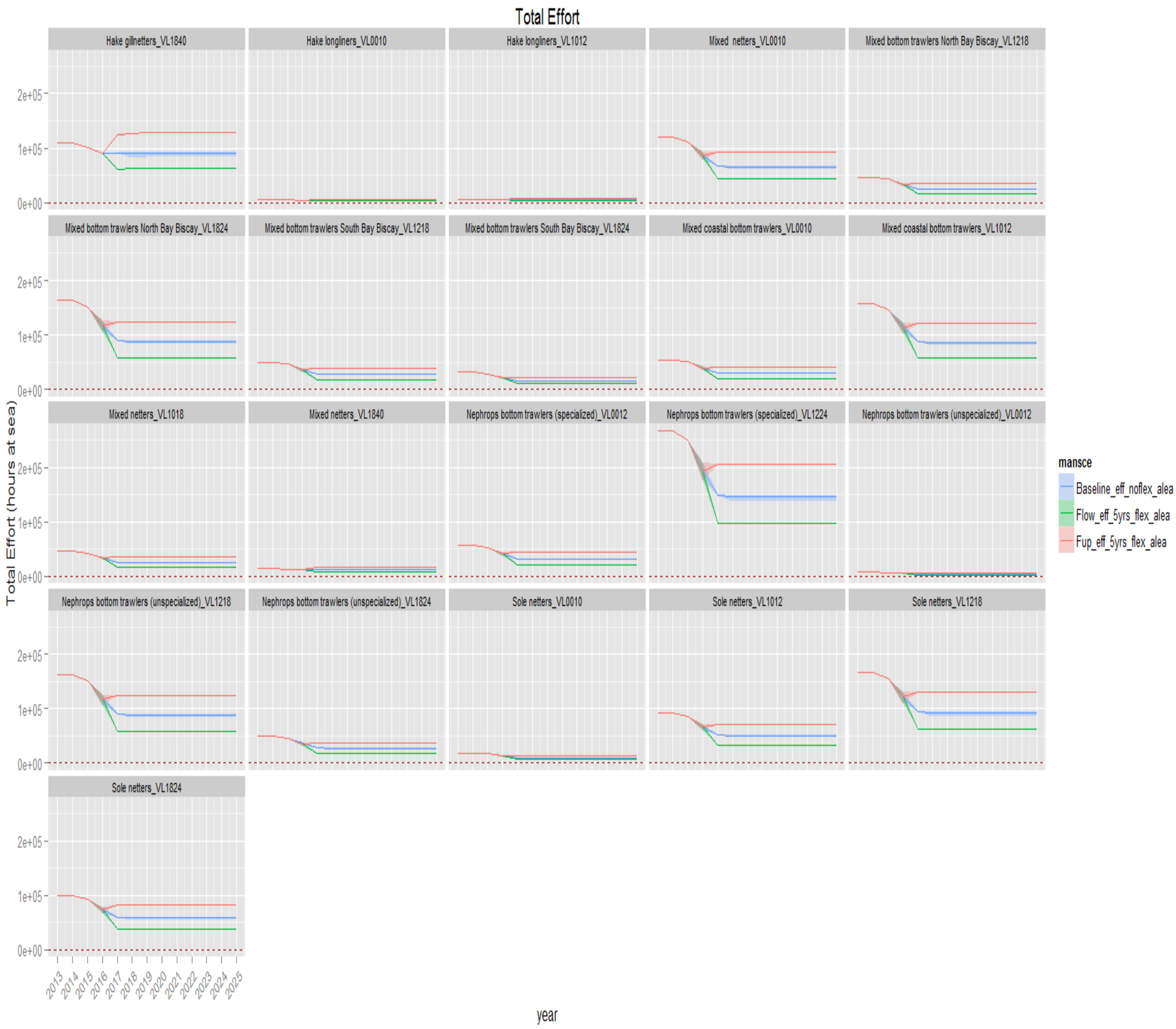
Recovery of SSB is observed for the 3 species and the 3 scenarios as a consequence of the decrease in F (Figure 8).
Nb Historical evolution of the SSB for sole shows that SSB have been below Bpa from end 90's to 2010.

5.2. Impacts on effort

Figures 9 to 11 represent evolution of indicators by fleet with a common graphic scale to highlight main variations in absolute value. Effort variations by fleet result from reconciliation and safeguards mechanisms and assumptions of no possible reallocation of effort.

Assumption of the simulation is that effort adjustment to reach objectives is uniform between fleet and métier catching hake and/or sole. Description of joint productions in the fishery show that hake gillnetters and longliners only catch hake (and thus adjust to hake objectives) and that all the other fleets trawlers and netters have joint productions of hake and sole for most of the métiers at the year level of simulation and thus adjust to the minimum of effort compatible with hake or sole objective (through reconciliation process defined).

Figure 9: Evolution of total effort by modeled fleet according to scenarios and reconciliation of objectives- Outputs IAM



Initial distance to FMSY is 45% for sole initially and 27% for hake. Decrease in effort by fleet observed is the results of the decrease of effort by fleet and métier according to reconciliation and fleets joint productions. As a result, we observe in the simulations that fleets specialized on hake (hake gillnetters and longliners) have lower decrease in effort (-17 to 20% in the baseline compared to effort in 2013) than other fleets catching also for sole that have reduction in effort of 41% to 50% in the case of the baseline scenario. Total decrease by fleet depends on the effort by fleet allocated to other métier catching neither sole nor hake.

Table 14 : Variation of effort 2020 compared to initial effort in 2013 by fleet and scenario

	Variation of effort 2020 to 2013		
fltsegment	Baseline	Flow	Fup
Hake gillnetters_VL1840	-17%	-43%	17%
Hake longliners_VL0010	-17%	-43%	17%
Hake longliners_VL1012	-20%	-45%	13%
Mixed netters_VL0010	-45%	-64%	-23%
Mixed bottom trawlers North Bay Biscay_VL1218	-46%	-64%	-25%
Mixed bottom trawlers North Bay Biscay_VL1824	-46%	-64%	-25%
Mixed bottom trawlers South Bay Biscay_VL1218	-45%	-64%	-23%
Mixed bottom trawlers South Bay Biscay_VL1824	-50%	-67%	-30%
Mixed coastal bottom trawlers_VL0010	-45%	-64%	-23%
Mixed coastal bottom trawlers_VL1012	-45%	-64%	-23%
Mixed netters_VL1018	-45%	-63%	-23%
Mixed netters_VL1840	-17%	-43%	17%
Nephrops bottom trawlers (specialized)_VL0012	-45%	-64%	-23%
Nephrops bottom trawlers (specialized)_VL1224	-45%	-63%	-23%
Nephrops bottom trawlers (unspecialized)_VL0012	-46%	-64%	-24%
Nephrops bottom trawlers (unspecialized)_VL1218	-45%	-64%	-23%
Nephrops bottom trawlers (unspecialized)_VL1824	-45%	-64%	-23%
Sole netters_VL0010	-44%	-63%	-22%
Sole netters_VL1012	-45%	-63%	-22%
Sole netters_VL1218	-44%	-63%	-22%
Sole netters_VL1824	-41%	-60%	-17%

Reconciliations assumptions with uniform distribution of decrease in F by fleet is close to a conservation of the historical catch shares by fleet (with however size effects that can operate). Surveys with Producer Organizations and disaggregated analysis of the management and landings by fleet under constraints of a decreasing TAC would enable to precise, valid or invalid this assumption.

Under constraint of a decreasing TAC, the system of pooling and redistribution of quotas operated by PO in France could adjust and allocate decrease differently among fleets according to contributions to fishing mortality for example. By assuming that effort reallocation would not happened, focusing on specialized fleets, socio-economic impacts would be minimized with however potential territorial and social impacts.

5.3. Economic impacts

Figure 10 : Evolution of total gross value added by modeled fleet according to scenarios and reconciliation of objectives- Outputs IAM*

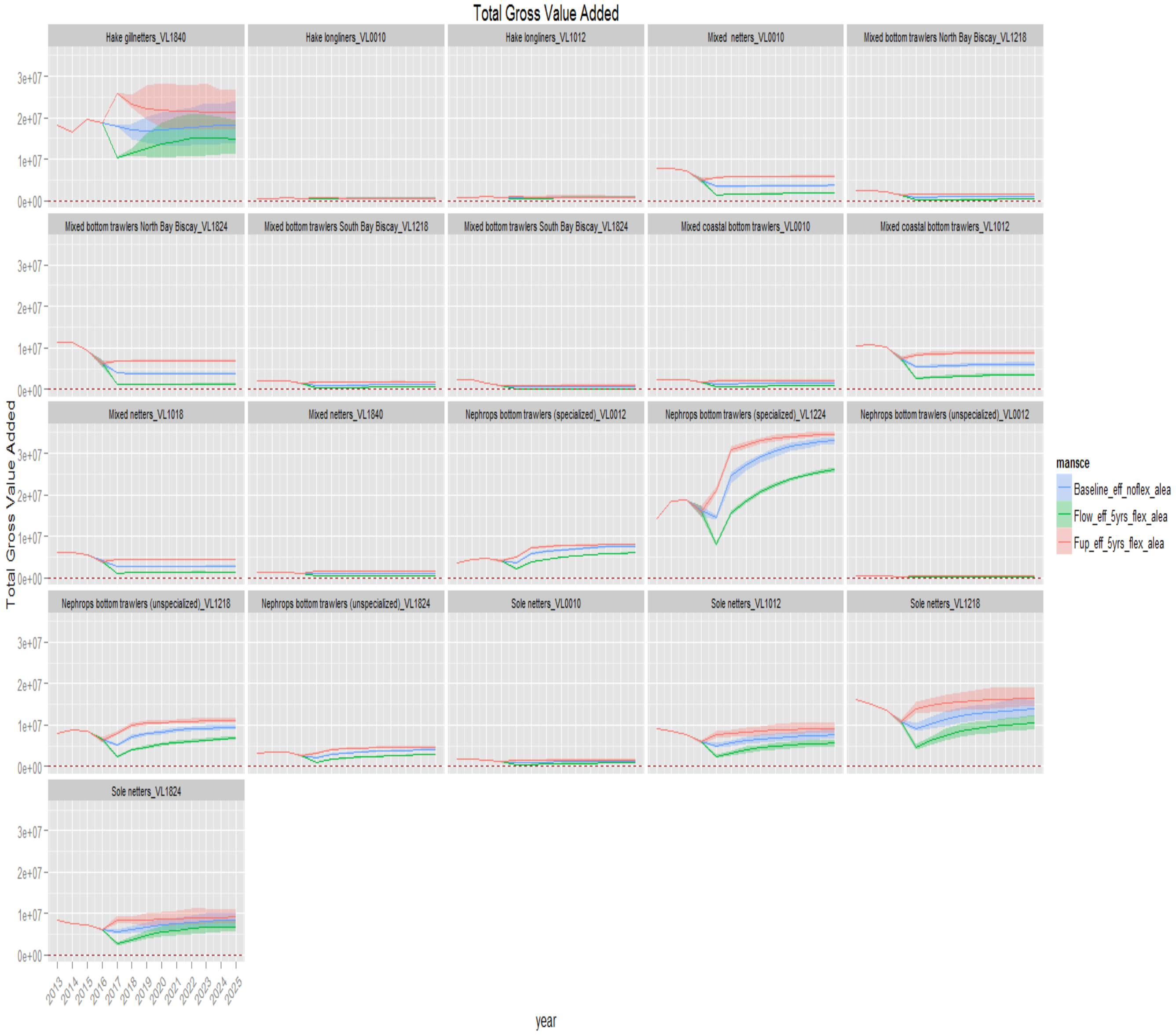
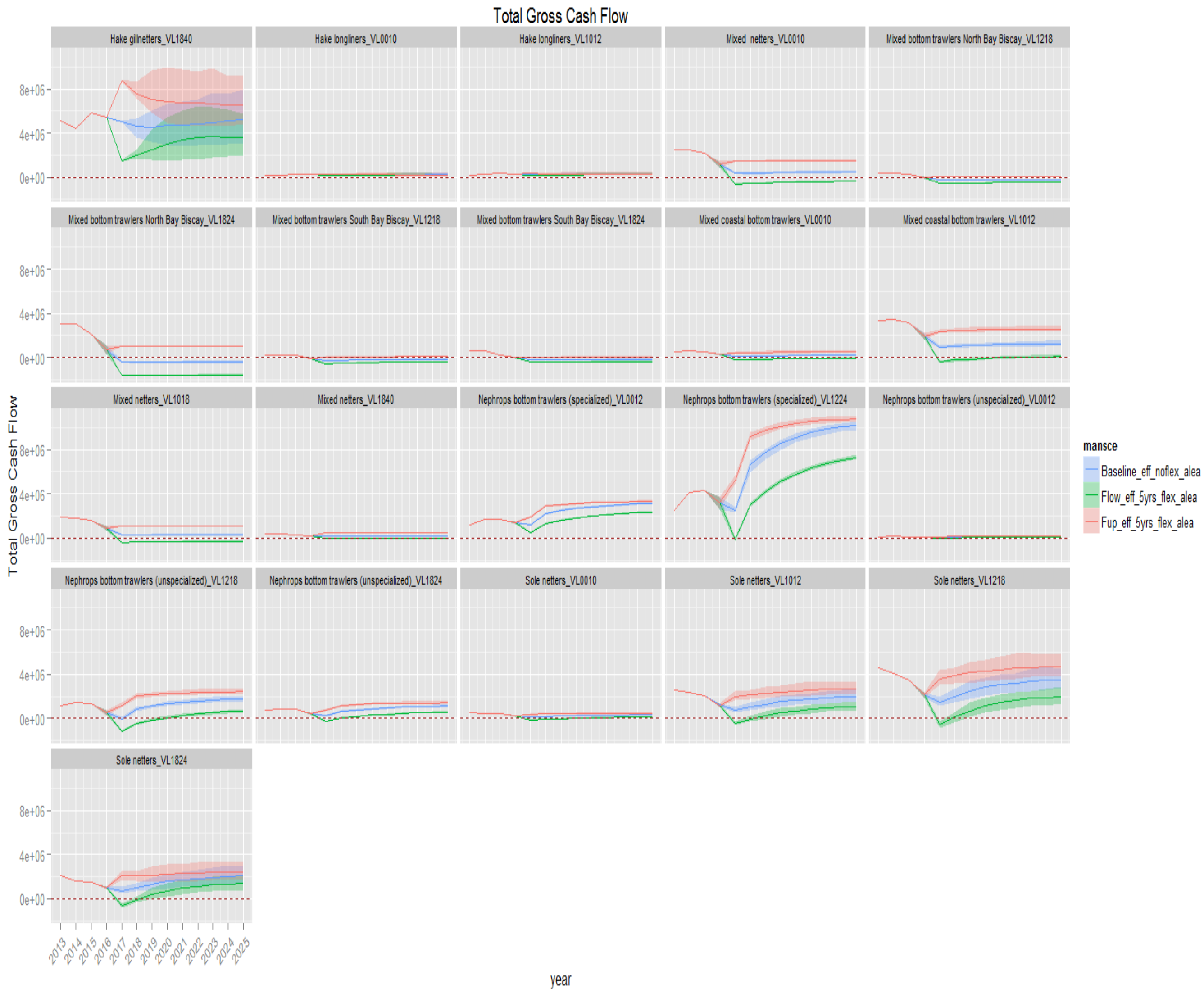


Figure 11 : Evolution of total gross cash flow by modeled fleet according to scenarios and reconciliation of objectives-Outputs IAM



Most impacted fleets

Analysis of economic impacts by fleet of the 3 scenarios (under assumptions) highlights that (figure 11):

- In the baseline, mixed bottom trawlers over 12 meters (North and South) have endangered economic viability (GCF< 0 or close to 0).
- In the Fup scenarios, only southern mixed bottom trawlers 12-18 meters show endangered short term economic viability while other fleets show higher economic performances
- In the Flow scenarios, short term economic viability of most of the fleets is endangered. Mixed netters and bottom trawlers show negative GCF all along the simulation period while sole netters and non-specialized nephrops bottom trawlers highlight variable transition period of 4 to 5 years with negative GCF.

Table 13 highlights that due to high decreases in effort and costs compared to yields, mixed bottom trawlers (12-18m in particular) would be the most impacted fleets in terms of gross cash flow variation compared to 2013 (assuming no possible reallocation of effort and constant number of vessels). Important impacts on those fleets are linked with joint productions of sole assumed at the métier-fleet level and the assumption of no possible reallocation of effort. Mixed and Sole netters would also have important decreases of their GCF compared to the initial period. Unspecialized nephrops trawlers over 12 m would be also impacted in the short term in particular in scenario Flow. Fleets specialized on hake and nephrops trawlers would benefit from the MAP due to hake and nephrops stock recovery and low effort reductions for those fleets. Results of Flow scenario show negative impacts compared to initial period for most of the fleets.

	Baseline_eff_noflex_alea			Flow_eff_5yrs_flex_alea			Fup_eff_5yrs_flex_alea		
	2017	2021	2025	2017	2021	2025	2017	2021	2025
Hake gillnetters_VL1840	-1%	-7%	1%	-71%	-34%	-29%	71%	33%	28%
Hake longliners_VL0010	34%	28%	39%	-27%	26%	31%	93%	37%	30%
Hake longliners_VL1012	22%	16%	26%	-32%	5%	5%	76%	37%	32%
Mixed netters_VL0010	-85%	-82%	-80%	-124%	-117%	-115%	-43%	-40%	-39%
Mixed bottom trawlers North Bay Biscay_VL1218	-172%	-164%	-162%	-247%	-234%	-230%	-91%	-85%	-84%
Mixed bottom trawlers North Bay Biscay_VL1824	-112%	-113%	-113%	-154%	-153%	-152%	-66%	-66%	-66%
Mixed bottom trawlers South Bay Biscay_VL1218	-202%	-174%	-165%	-309%	-266%	-255%	-88%	-74%	-70%
Mixed bottom trawlers South Bay Biscay_VL1824	-128%	-125%	-124%	-161%	-154%	-152%	-94%	-92%	-92%
Mixed coastal bottom trawlers_VL0010	-85%	-68%	-63%	-141%	-119%	-113%	-26%	-13%	-10%
Mixed coastal bottom trawlers_VL1012	-72%	-65%	-63%	-111%	-100%	-98%	-31%	-25%	-25%
Mixed netters_VL1018	-83%	-84%	-83%	-121%	-117%	-117%	-41%	-43%	-43%
Mixed netters_VL1840	-42%	-44%	-43%	-117%	-113%	-113%	41%	45%	45%
Nephrops bottom trawlers (specialized)_VL0012	0%	135%	156%	-57%	64%	94%	57%	163%	170%
Nephrops bottom trawlers (specialized)_VL1224	1%	263%	307%	-104%	130%	190%	108%	313%	328%
Nephrops bottom trawlers (unspecialized)_VL0012	-63%	9%	22%	-120%	-54%	-36%	-3%	55%	59%
Nephrops bottom trawlers (unspecialized)_VL1218	-103%	24%	48%	-201%	-78%	-46%	-1%	95%	104%
Nephrops bottom trawlers (unspecialized)_VL1824	-71%	31%	51%	-142%	-48%	-21%	2%	84%	92%
Sole netters_VL0010	-79%	-54%	-45%	-125%	-92%	-80%	-31%	-18%	-12%
Sole netters_VL1012	-71%	-36%	-24%	-116%	-74%	-59%	-24%	-4%	3%
Sole netters_VL1218	-69%	-34%	-24%	-113%	-69%	-57%	-22%	-4%	2%
Sole netters_VL1824	-65%	-17%	0%	-129%	-54%	-34%	0%	10%	17%

Table 15: Variation of Gross Cash Flow compared to initial period (2013), sources outputs IAM

Differences in impacted fleets according to scenarios, depend mainly on:
- métiers by fleet, reconciliation process and choke effects assuming no possible reallocation of effort
- dependence and contribution to the different species managed and ability to benefit from stocks recoveries.

Limits

In all scenario tested, we assumed no effort reallocation to other métiers. Such assumption has been discussed in focus groups from the SOCIOEC EU project (http://www.socioec.eu/) in the case of the sole management plan and some data analyses were even conducted in the National Bio-economic partnership Working Group. They showed that the reallocation of effort to other species in the bay of Biscay is probably very limited for trawlers but can be possible for some netters (SOCIOEC D5.3, 2014, Macher et al, 2011, 2013). In this project, opportunity and constraints associated with the reallocation of effort to the main optional species of the Bay of Biscay (in particular sea bass, monkfish, Pollack or red mullet) were also discussed with fishermen representatives (including Producers Organisations) and issues related to stock abundance, market, quota constraints, access regulation through permits or rights and fishing techniques were addressed. The main conclusions of this consultation can be summarized as follows:

"- trawler fleets would have very little opportunities of reallocation of effort to respect the sole quota that they fish all along the year. A decrease in the sole quota would thus imply a decrease in the number of days at sea.

- Small gillnetters fleets could have small possibilities to reallocate their fishing effort on hook métiers targeting Pollack, seabass, megrim or whiting

- Larger gillnetter fleets could have small possibilities to reallocate their fishing effort on monkfish and lower possibility on hake or whiting that have low valorizations.

Results show that possibility to reallocate effort in the Bay of Biscay remains limited because of low abundances of stocks, access regulation or market or quota constraints of other species."

Sea bass is seen as an option for reallocation for some of the fleets in particular for netters for which access to this resource is possible, negative impacts of MAP on sole and hake are to be expected on this species.

Negative impacts assessed through the model also depend on the technical interactions that are parameterized through correlations between species at the fleet-métier level. Fishermen could indeed limit the impacts expected by adjusting their productions functions through spatio-temporal allocation of their effort and fishing techniques according to the constraints. Impacts of the MAP on the main species would thus be limited on other species.

5.4. Social impacts

Constant number of vessels by fleet is assumed in the simulations (see table 11). By assuming a constant number of crew members and a constant crew share remuneration system, the total employment in the fishery remains constant as well over the simulation (2256 fishermen). Mean wages by fisherman would thus follow the same tendency by fleet as the gross cash flow. This is due to the share system which leads to decrease in wages for fleets decreasing their return to be shared.

Analyses of crew share over time show however that crew share have been a variable of adjustment in the strategies of some fleets and have been increased in some fleet in the context of limitation of labor supply (see socioec EU project, http://www.socioec.eu/) and the need to maintain attractiveness for skilled crew members. This could tend to limit the expected negative impacts for crew (and increase expected negative impacts for owners).

Assumptions of increase of the number of crew due to landings obligation and sorting constraints have been tested but are difficult to parameterize in the absence of survey on sorting behaviours and constraints. Economic impact of landing obligation is also very dependent on the negotiations that could occur on the distribution of the impacts of the LO between owners and crew and the remuneration system that can be decided for extra-crew member hired to sort unwanted catches.

Spatial distribution of fleets and dependence of harbors to sole and hake show that territorial impacts can be expected in the southern harbours of the bay of Biscay (Arcachon, Marennes, Noirmoutier, and Yeu and Sables d'Olonne). Other harbours, less dependent on sole and hake but that have high dependency to the mix of demersal species caught together with sole and hake, could also be impacted however.

5.5. Governance

Analysis of the landings objectives (corresponding to F allocation by fleet without reconciliation) with the landings realized show that choke effects remain limited (with assumptions of joint productions of sole and hake at the fleet-métier level defined in the model). In the case of sole, TAC and landings match as sole objectives drive the system (figure 13). In the case of hake, for mixed fleets, light choke effects are observed due to sole at the beginning of the simulation (figure 12).

Figure 12 : Comparison of hake landings corresponding to F objective by fleet (~quota by fleet) and landings corresponding to realized F after reconciliation - Outputs IAM

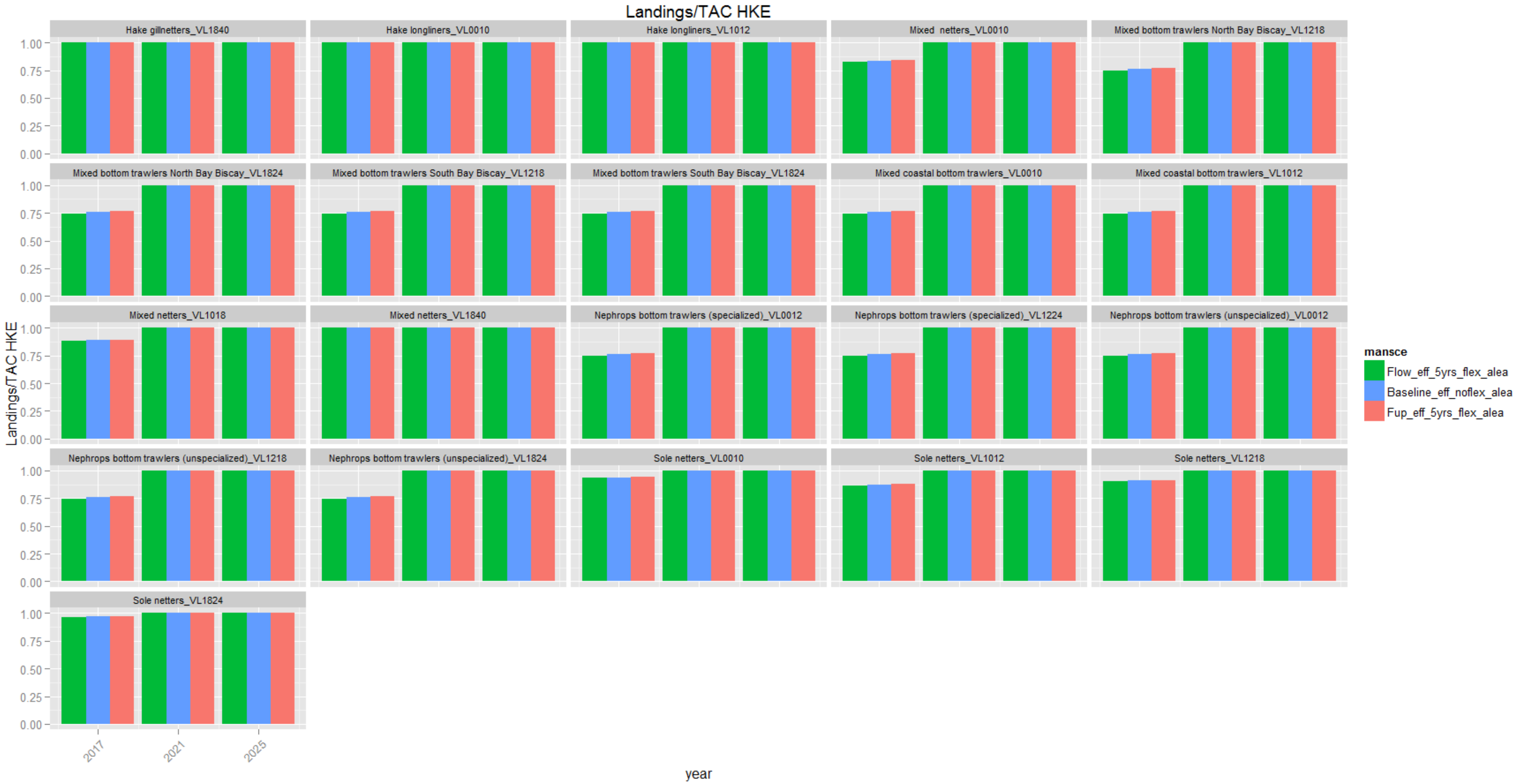
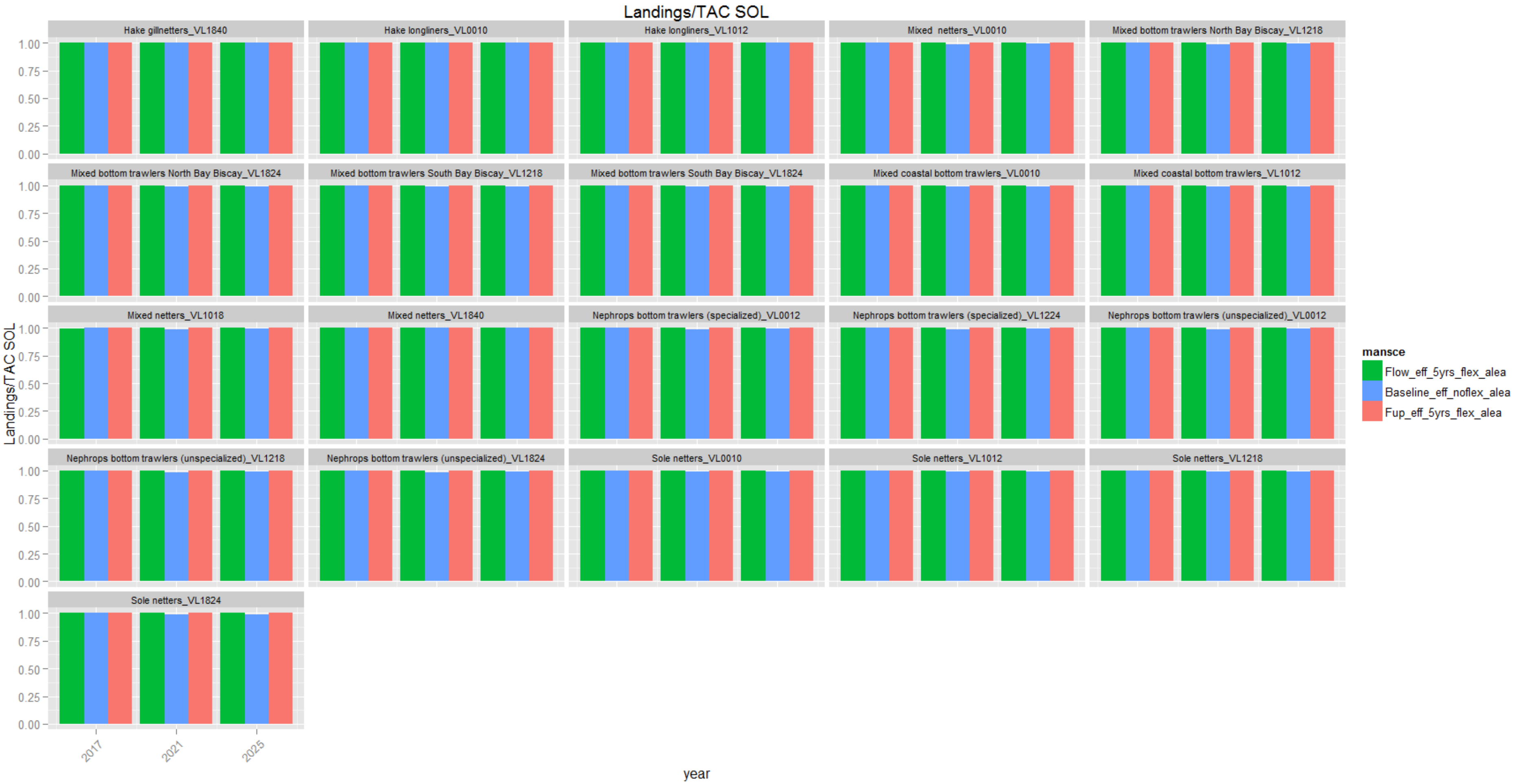


Figure 13 : Comparison of sole landings corresponding to F objective by fleet (~quota by fleet) and landings corresponding to realized F after reconciliation - Outputs IAM



6. Discussion conclusions

Approach adopted was to compare biological status of stocks and fleets economic viability in the baseline scenario following current rules under the CFP (with however no flexibility assumed for the implementation of the landing obligation) compared to the extreme envelope of the MSY range approach which is the basis of MAP as being defined (Flow for all the species or Fup for all the species).
Compatibility of ranges of MSY according to technical interactions in a multi-species approach was not specifically tested. Management scenarios by species with assessment of the impact of the variation of F for one species on the other species through technical could provide an interesting highlight of the choke effects and the value added of having compatible MSY ranges.

Results highlight the impact of the management of hake and sole. It should be however underlined that joint productions were modeled at the fleet métier level in the model. At this level, hake, sole and/or nephrops (but also other species caught in the Bay of Biscay but whose dynamic was not explicitly modeled) can be caught together with sole and/or hake. Managing sole and/or hake thus improve also hake, sole and nephrops in the model. However, joint production process operates at the fleet-métier-saison-area level. By allocating effort differently among métier, area and season there is thus ability for fishermen to adjust to a certain extent the correlation between species and thus to reconcile different objectives. Maps from Gepeto thus show the spatial distribution of landings of main species in the bay of Biscay and highlight that sole is caught on coastal area, while nephrops is caught in the grande Vasière and hake has a wider distribution and thus more interactions with sole on one side and nephrops on the other side. At the fleet level: Entry/exit due to economic dynamics or due to management by PO of their members fishing plan can modify species correlations, at the vessel level: spatio-temporal allocation of effort by métier change the correlations between species.

The 3 scenarios tested provide an envelope approach of the potential impacts of each scenario. Impacts are assessed for each of the scenarios tested with results depending however on the level of definition of the correlations between species and on the behaviors modeled.

Main stakes of the implementation of MAP are however to reconcile the fishing possibilities in a multi-species context. A complementary approach to analyze the value added of MAP could be to apply innovative viability approaches to find the set of effort by fleet and métier (area and month) which enable to respect constraints of MSY ranges for all the stocks and Bpa constraints if any and to assess potential socio-economic impacts of those solutions (if any). This approach would enable to show first if there are solutions of effort by fleet and métier such that F of the different stocks belong to the ranges and Bpa are respected and then to identify a set of solution that can be chosen by the fishermen in this area of constraints where a subset of economical viable solutions can be identified (if any?).

It should be underlined that economic impacts assessed for fleets depend on a number of assumptions of the simulations (no reallocation of effort, adjustment of fishing time with constant capacity, uniform adjustment of effort between fleet, joint productions defined at fleet-métier level…).

Other simulations conducted for sole in the bay of Biscay have highlighted the stakes of capacity adjustment to fishing possibilities. Capacity is here assumed to remain constant over the simulation.

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List of the tables and figures