Supplementary Material A

Metier analysis for the SESSF

The aim of this analysis was twofold:

- define metiers for the South East Shark and Scalefish Fishery (excl. the Great Australian Bight and East Coast Deepwater Trawl sectors),
- define fleets for the South East Shark and Scalefish Fishery (excl. the Great Australian Bight and East Coast Deepwater Trawl sectors).

The metier analysis builds on the definition used by the European Data Collection Framework [EU, 2008, 2010], which is "a group of fishing operations targeting a similar (assemblage of) species, using similar gear, during the same period of the year and/or within the same area and which are characterised by a similar exploitation pattern". Multivariate statistical methods have often been used to identify groups of trips with similar landings compositions [Marchal, 2008, Deporte et al., 2012, Ziegler, 2012, Ono et al., 2018]. A similar approach has been undertaken here, but on the species composition of the landed value rather than the landed weight since targeting is most likely to be driven by the value of landings than their weight.

A fleet, on the other hand, is defined here as a group of vessels showing similar fishing practices, in other words showing similar effort allocations among metiers. Here again, statistical clustering methods were used to identify groups of vessels showing similar fishing practices.

A.1 Material and Methods

A.1.1 Data

The species composition of landed catch was derived from the fishery's logbook data. In order to have a recent description of the fishery only records from calendar years 2012 to 2017 were used. Annual fish prices were retrieved from the Australian fisheries and aquaculture statistics report Mobsby [2018].

A.1.2 Definition of metiers

The definition of metiers consisted in 2 main steps:

1. A clustering of fishing hauls based on landings profiles (in value) using multivariate statistical methods,

2. A post-hoc refinement of the clusters identified by the clustering algorithm in order to: (2.1) group clusters that do not show significant differences in terms of value profile, and (2.2) make sure that clusters reflect an intended targeting based on expertise from members of the fishing industry.

Step 1: Statistical clustering:
The analysis follows the first 3 steps of the workflow developed by Deporte et al. [2012] and integrated in the R package *vmstools*:

1.1: Identification of the main species in order to reduce the dataset to these key species. Species were selected so that at least 90% of the total value and 70% of each haul value was represented in the final dataset to cluster.

1.2: Investigation of running a Principal Component Analysis (PCA) on the dataset prior to the clustering. The reason for applying a PCA to the dataset is that it reduces the number of variables in the dataset to cluster (initially, the variables are the individual species but when running a PCA variables become the relevant factors from the PCA).

1.3: Running a selection of clustering algorithms and dissimilarity measures. In order for large and small hauls to be given equal importance, the clustering was done on the species contribution to the haul value (the sum of which, across all species, equals 1), rather than absolute values of catch. The input to the clustering algorithm is therefore a 2D matrix M, with rows referring to logbook events (index le), and columns to species (index sp), and entry $M_{le,sp}$ defined as: $M_(le, sp) = \frac{p_{sp} * L_{le,sp}}{\sum_{sp} p_{sp} \times L_{le,sp}}$, with p_{sp} the price of species sp, and $L_{le,sp}$ the landed catch of species sp in logbook event le.

For the sake of brevity, only the most satisfactory results will be presented in this document. They were obtained by running the CLARA algorithm on the original dataset (i.e. without prior PCA) with the Euclidean distance used as the dissimilarity metric. Nonetheless, alternative choices for steps 1.2 and 1.3 were explored and the reason for discarding them provided hereafter:

- Step 1.2: The clustering analysis was performed on four different datasets: the original dataset with species as variables, and three PCA-transformed datasets respectively keeping factors representing 70% of the explained variance, 80% of the explained variance, and as determined by the Scree test. The Scree test retains fewer axes than thresholds of 70% or 80% of explained variance, which then results in fewer clusters. The clustering of PCA-transformed data also leads to fewer clusters than the clustering

of original data and failed at identifying rare (but existing) metiers. This for instance concerns the targeting of orange roughy since the fishery has only reopened in 2015 in some areas. In order not to miss rare but important metiers throughout the clustering process, we decided to keep working with the original dataset, without prior dimension reduction.

- Step 1.3: Three clustering methods were implemented in the *vmstools* package: HAC, K-means and PAM (or its adaptation for the analysis of large datasets: CLARA). HAC and CLARA algorithms gave similar results, unlike K-means (in line with tests run by Deporte et al. [2012]). The CLARA algorithm was finally chosen since more efficient on large datasets. Sensitivity of the results to the distance metric used to cluster the data was also investigated. The Euclidean and Manhattan distances are two commonly used dissimilarity measures in clustering analyses. We observed that the Euclidean distance allowed identifying single species clusters (e.g. royal red prawn trawling) which did not emerge with the Manhattan distance. Since those single-species metiers are important for the fishery, we decided to work with the Euclidean distance rather than the Manhattan distance.

Multispecies technical interactions are also sensitive to the scale at which data is analysed and working with spatially or temporally aggregated data can only increase the level of perceived interactions. Therefore, data was kept at the finest scale as possible, i.e. at the haul level. Not aggregating data however requires the clustering algorithm to work on a large dataset which has been solved by using a variant of the PAM algorithm suited to the analysis of large datasets (CLARA). In addition, separate clustering analyses were run for each of the 5 groups specified in Table A.1 which reduced the size of the dataset to cluster and resulted in more relevant clusters. The East-West boundary is the 147-degree meridian (also used in the management of certain stocks).

Table A.1: Gear classification and groups used for clustering

Sector	Gear	Abbreviation in logbook	Group for clustering	Nb. of events in 2012-2017
CTS	Otter trawl	TDO,TW	Trawl - East	59383
			Trawl - West	21044
	Danish seine	DS	Danish seine	54984
GHTS	Gillnet	GN	Gillnet	42528
	Automatic longline	AL	Hooks	17042
	Bottomline	BL		
	Dropline	DL		

Step 2: Refinement of clusters: This refinement phase consisted in two phases:

2.1: The grouping of clusters that had similar value profiles

2.2: Based on expert knowledge of the fishery, clusters whose landed value was dominated by species that are not identified as targeted species by members of the fishing industry were assigned to a "mixed" metier as they are likely to be the result of chance than intended targeting.

A.1.3 Definition of fleets

A similar approach using statistical clustering was used to define fleets for the SESSF. As metiers were clusters of hauls having similar landings profiles, fleets are clusters of vessels displaying similar fishing patterns (or metier profiles). A vessel's fishing pattern as the allocation of its annual fishing effort across the different metiers. Input of the clustering algorithm is therefore a 2D matrix F, with rows referring to vessels (index v), and columns to metiers (index m), and entry $F_{v,m}$ defined as: $F_{v,m} = \frac{Eff_{v,m}}{\sum_m Eff_{v,m}}$, with $Eff_{v,m)}$ the number of hauls vessel v operated in metier m.

This analysis builds on the allocation of hauls to metiers carried out previously. To be consistent with the methods used in the metier identification, the PAM algorithm was used to identify fleets (CLARA was not necessary as the sample size is now smaller, i.e. the number of vessels). The clustering algorithm was run separately for the 4 sectors: Trawl (East and West regions were not treated separately as some trawlers operate across the 2 zones), Danish seine, Gillnet and Hooks.

Similarly to the metier analysis, similar clusters were merged as a post-hoc refinement (step 2). This step was specifically important to ensure the inter-annual stability of fleets and not having vessels move between fleets from one year to another without having significantly changed their fishing practices.

A.2 Results

A.2.1 Metiers

Table A.2 describes the species composition of the clusters identified at Step 1 and provides the number of hauls in each cluster. It also specifies how each cluster has then been attributed to a metier through Steps 2.1 and 2.2. After Step 1, respectively 15, 6, 6, 7 and 6 clusters were identified for Trawl East, Trawl West, Danish seine, Gillnet and Hooks. After Step 2, those cluster have been merged into respectively 10, 6, 3, 1 and 4 metiers. When mixed clusters were found across a wide range of depths (e.g. cluster 3 of Trawl West), their hauls were attributed to the mixed shelf when operating at depths smaller than 250m and to the mixed slope metier when operating at depths greater than 250m. Further details on the defined metiers are provided in Supplementary file metiers_SESSF.xlsx.

A.2.2 Fleets

Table A.3 summarizes the fleet identification derived from the clustering analysis of vessels' fishing patterns. After Step 1, respectively 6, 10, 9 and 6 clusters were identified for Trawl, Danish seine, Gillnet and Hooks. After Step 2, those cluster have been merged into respectively 5, 2, 1 and 5 fleets.

Table A.2: Description of clusters and attribution to metiers

Sector	Cluster Step 1	Species composition		Depth zone	Zone	Main season	% hauls	Cluster Step 2.1	Cluster Step 2.2 (metier)	Remarks
		Main species	Secondary species							
Trawl East	13	Flathead (87%)		Shelf	10;20;30	All year	23	Flathead	Flathead	
	1	Flathead (61%)	John dory, squids, latchet, ocean jackets, other species	Shelf	10;20;30	All year	24	Flathead	Flathead	
	2	Royal Red Prawn (87%)	Mirror dory, other species	Slope	Ulladulla	All year	3	Royal Red Prawn	Royal Red Prawn	
	3		Flathead, John dory, squids, other species	Shelf	10;20;30	All year	12	Mixed Shelf	Mixed Shelf	
	4	Ocean jackets (43%)	Flathead,John dory	Shelf	10;20	Except winter	5	Ocean jackets	Ocean jackets	
	5	Jackass Morwong (53%)	Flathead, ocean jackets, squids, other species	Shelf	20	Summer	3	Jackass morwong	Jackass morwong	
	7	Silver trevally (62%)	Flathead, ocean jackets, other species	Shelf	10	Dec-Jan; April-June	3	Silver Trevally - Flathead	Mixed Shelf	Silver Trevally not targeted
	11	School whiting (57%)	Flathead, other species	Shelf	10	April - May	2	School Whiting	Mixed Shelf	School Whiting not targeted
	12		Other species (65%), flathead, squids	Shelf-Slope	10;20;30	All year	3	Mixed (shelf-slope)	Mixed (shelf-slope)	
	9	Squids (60%)	Flathead	Shelf-Slope	10;20;30	Summer - Autumn	5	Squids	Squids	
	10	Pink Ling (69%)	ocean perch offshore, blue grenadier, mirror dory	Slope	20	Not in summer	7	Pink Ling	Pink Ling	
	6	Ocean perch offshore (59%)	Pink ling, Mirror dory, gemfish, other species	Slope	10	July - October	3	Ocean perch - Pink Ling	Mixed Slope	Ocean Perch not targeted
	8		Blue grenadier, mirror dory, pink ling, ocean perch offshore	Slope	10;20;30	All year	6	Mixed Slope	Mixed Slope	
	14	Frostfish (60%)	mirror dory, pink ling	Slope	10;20;30;	Winter	2	Frostfish	Frostfish	
	15	Orange roughy (90%)	oreos	Deep	St Helens	Not in summer	1	Orange Roughy	Orange Roughy	

Description of clusters and attribution to metiers, continued

Sector	Cluster Step 1	Species composition		Depth zone	Zone	Main season	% hauls	Cluster Step 2.1	Cluster Step 2.2 (metier)	Remarks
		Main species	Secondary species							
Trawl West	4		deepwater flathead, squids, silver warehou, latchet, other species	Shelf-Slope	50	Winter - Spring	25	Mixed (shelf-slope)	Mixed (shelf-slope)	
	3	Squids (58%)	silver warehou, mirror dory, pink ling, blue grenadier	Shelf-Slope	50	Summer - Autumn	13	Squids	Squids	
	2	Pink ling (75%)	blue grenadier, king dory, silver warehou	Slope	40	Spring	13	Pink Ling	Pink Ling	
	5	Blue grenadier (79%)	Pink ling	Slope	40-50	Winter	14	Blue Grenadier	Blue Grenadier	
	1		blue grenadier, pink ling	Slope	40-50	Summer - Autumn	25	Mixed slope	Mixed slope	
	6		deepwater sharks, oreos, ribaldo, orange roughy	Deep	40-50	Spring - Summer	10	Deepwater basket	Deepwater basket	
Danish seine	1	Flathead (48%)	gummy shark, other species	Shelf	20	Drop in summer	13	Flathead	Flathead	
	2	Flathead (85%)		Shelf	20	Drop in summer	22	Flathead	Flathead	
	3	Flathead (98%)		Shelf	20	Spring - Summer	42	Flathead	Flathead	
	4	School whiting (91%)		Shelf	20	Drop in summer	12	School Whiting	School Whiting	
	5	School whiting (58%)	Flathead, other species	Shelf	20	Drop in summer	9	School Whiting	School Whiting	
	6		Other species (72%), school whiting, flathead	Shelf	20	Winter-Spring	2	Mixed	Mixed	

Description of clusters and attribution to metiers, continued

Sector	Cluster Step 1	Species composition		Depth zone	Zone	Main season	% hauls	Cluster Step 2.1	Cluster Step 2.2 (metier)	Remarks
		Main species	Secondary species							
Gillnet	5	Gummy shark (98%)		Shelf	50-60	Spring-Summer	33	Gummy Shark	Gummy Shark	
	1	Gummy shark (92%)	saw shark	Shelf	50-60	Spring-Summer	32	Gummy Shark	Gummy Shark	
	2	Gummy shark (76%)	saw shark	Shelf	50-60	Spring-Summer	18	Gummy Shark	Gummy Shark	
	4	Gummy shark (62%)	school shark	Shelf	50-60	Autumn	6	Gummy Shark	Gummy Shark	
	6	School shark (67%)	gummy shark	Shelf	50-60	Autumn	4	School Shark	Gummy Shark	school sharks not targeted
	7		other species, gummy shark	Shelf	50-60	More in winter	4	Mixed	Mixed	
	3		saw shark, gummy shark, boarfishes	Shelf	60	More in winter	3	Mixed	Mixed	
Hooks	2	Gummy shark (97%)		Shelf	50	All year	44	Gummy Shark	Gummy Shark	
	1	Gummy shark (71%)	school shark	Shelf	50	All year	26	Gummy Shark	Gummy Shark	
	5	School shark (65%)	gummy shark	Shelf	50	Autumn; Spring	9	School Shark	Gummy Shark	school sharks not targeted
	4	Blue-eye trevalla (90%)		Slope	30	November - March	9	Blue eye Trevalla	Blue eye Trevalla	
	3	Pink ling (78%)	blue-eye trevalla, ribaldo, ocean perch offshore	Slope	30;40	Spring	5	Pink Ling	Pink Ling	
	6		other species, blue-eye trevalla, pink ling, snapper	Shelf - Slope	30;40;50	Not Winter	8	Mixed Scalefish	Mixed Scalefish	

Table A.3: Description of fleets

Sector	Step 1 Cluster	Metiers	Number of vessels x year	Step 2 (fleet)
Trawl	1	TW.West Slope (60%), TW.West.Shelf (15%), TW.West Blue Grenadier (9%), TW.West.Mixed.deepwater (8%)	67	Mixed Trawler West
	2	TW.East.Shelf (82%), TW.East.Slope (16%)	60	Mixed Trawler East
	3	TW.East.Shelf (63%), TW.East.Slope (30%)	50	Mixed Trawler East
	4	TW.East.Shelf (97%)	41	Shelf Trawler East
	5	TW.East.Royal.Red.Prawn (71%), TW.East Shelf (20%), TW.East.Slope (9%)	12	Royal Red Prawn Trawler
	6	TW.West.Blue.Grenadier (83%), TW.West.Slope (6%)	5	Blue Grenadier Trawler
Danish seine	1	DS.Flathead (90%), DS.School.Whiting (9%)	16	Flathead Danish seiner
	2	DS.Flathead (78%), DS.School.Whiting (20%)	27	Flathead Danish seiner
	3	DS.Flathead (84%), DS.School.Whiting (14%)	22	Flathead Danish seiner
	4	DS.Flathead (95%), DS.School.Whiting (4%)	7	Flathead Danish seiner
	5	DS.Flathead (100%)	5	Flathead Danish seiner
	6	DS.Flathead (70%), DS.School.Whiting (26%)	20	Flathead Danish seiner
	7	DS.School.Whiting (90%), DS.Flathead (8%)	3	School Whiting Danish seiner
	8	DS.School.Whiting (68%), DS.Flathead (31%)	2	School Whiting Danish seiner
	9	DS.School.Whiting (51%), DS.Flathead (48%)	3	School Whiting Danish seiner
	10	DS.School.Whiting (77%), DS.Flathead (20%)	2	School Whiting Danish seiner
Gillnet	1	GN.Gummy.Shark (97%)	48	Gillnetter
	2	GN.Gummy.Shark (90%)	29	Gillnetter
	3	GN.Gummy.Shark (82%)	12	Gillnetter
	4	GN.Gummy.Shark (93%)	30	Gillnetter
	5	GN.Gummy.Shark (100%)	45	Gillnetter
	6	GN.Gummy.Shark (75%), GN.Mixed (25%)	10	Gillnetter
	7	GN.Gummy.Shark (95%)	70	Gillnetter
	8	GN.Gummy.Shark (87%)	20	Gillnetter
	9	GN.Gummy.Shark (57%), GN.Mixed (43%)	3	Gillnetter
Hooks	1	BL.Gummy.Shark (99%)	102	Shark Bottomliner
	2	BL.Gummy.Shark (90%), BL.Mixed.Scalefish (6%)	60	Mixed Bottomliner
	3	BL.Gummy.Shark (66%), BL.Mixed.Scalefish (21%)	25	Mixed Bottomliner
	4	AL.Blue.eye.Trevalla (72%), AL.Mixed.Scalefish (14%), AL.Pink.Ling (12%)	18	Blue eye Autoliner
	5	DL.Blue.eye.Trevalla (91%)	44	Blue eye Dropliner
	6	AL.Pink.Ling (39%), AL. Mixed. Scalefish (22%), AL.Blue.eye.Trevalla (18%)	10	Mixed Autoliner

A.2.3 Stability of metiers over time

Figure A.1 shows the allocation of fishing effort among metiers at the fleet level between 2012 and 2017. It notably shows that fishing strategies at the fleet level have remained largely stable throughout the studied period. One can also note the absence of blue grenadier trawlers some years. This is explained by this fleet being composed of large factory vessels coming from New-Zealand that have not been consistently active in the fishery in recent years.

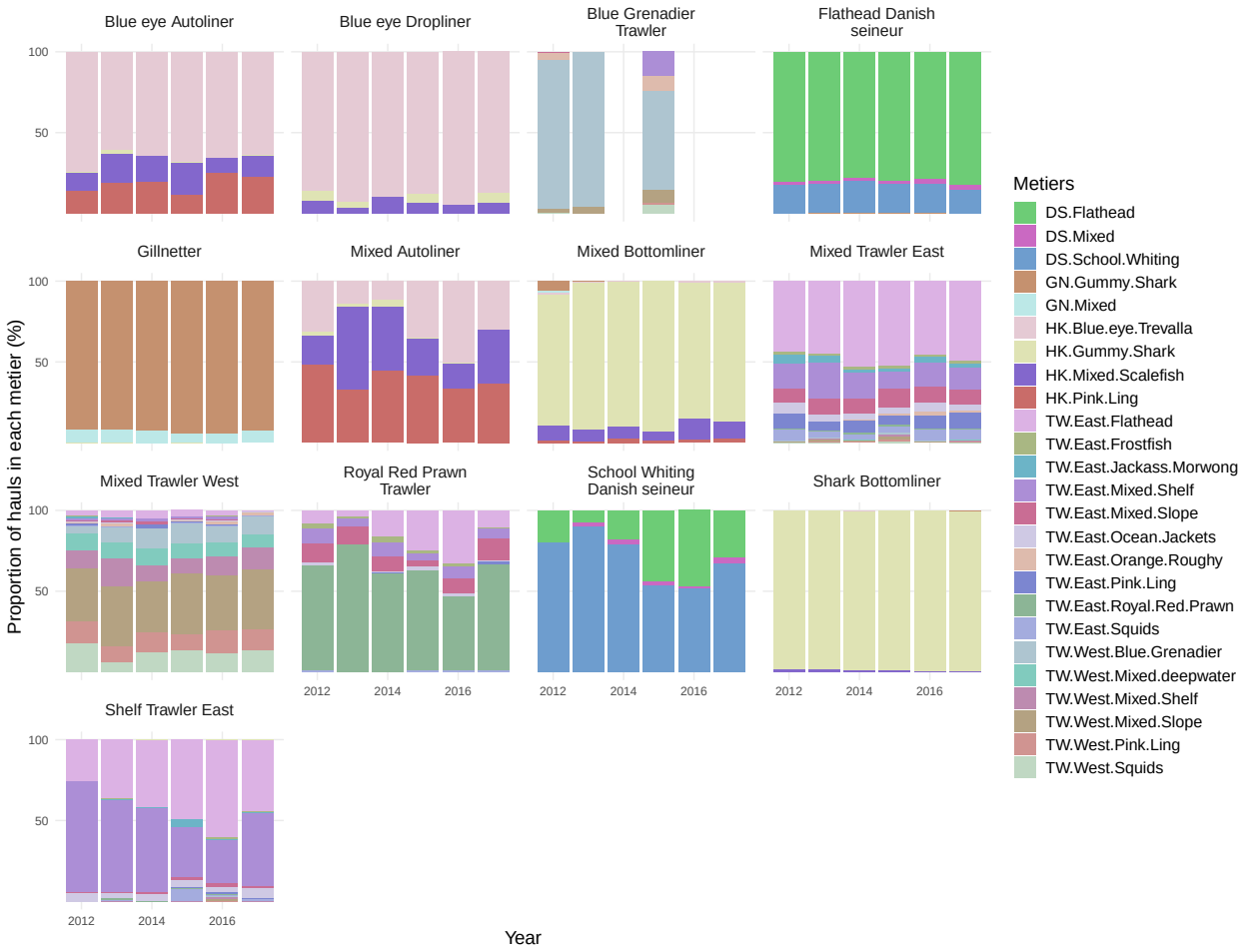

Figure A.1: Allocation of fishing effort by fleet and metier between 2012 and 2017. Metiers involving hook gears (i.e. bottomline, automatic longline and dropline) are all represented under "HK" metiers to limit legend entries and gear specificity is informed by the name of the fleet.

Supplementary Material B

Description of the IAM model

A list of the mentionned model's variables and associated subscripts is given in Table B.1.

Table B.1: IAM variables and associated subscripts

(a) Subscripts

s	species
mo	morph
a	age
g	gender
t	year
se	season
i	individual harvester
f	fleet
m	metier

Table B.1: IAM variables and associated subscripts, continued

(b) Variables

Variable	**Signification**	**Unit**
N	Number of individuals	$\emptyset$
N_0	Recruitment	$\emptyset$
B	Biomass	kg
K	Carrying capacity	kg
r	Growth rate	yr^{-1}
w	Individual weight	kg
wL	Individual weight in the landings	kg
Mat	% of mature individuals	$\emptyset$
$MatWt$	Mature weight	kg
SSB	Spawning Stock Biomass	kg
F	Fishing mortality rate	yr^{-1}
FLw	Mortality rate from landings in weight	yr^{-1}
FDw	Mortality rate from discards in weight	yr^{-1}
D	Discard rate	$\emptyset$
δ	Weighting coefficient for the calculation of $\overline{F}$	$\emptyset$
M	Natural mortality rate	yr^{-1}
Z	Total mortality rate $(F + M)$	yr^{-1}
E	Fishing effort	day
q	Catchability	$\text{year}^{-1}.\text{day}^{-1}$
L	Landings	kg
$LPUE$	Landings per unit of effort	kg.day^{-1}
p	Ex-vessel price	$\text{AU\$.kg}^{-1}$
qp	Lease price of quota	$\text{AU\$.kg}^{-1}$
GVL	Gross value of landings	AU$
$cshr$	Crew share	$\emptyset$
$rtbs$	Return to be shared	AU$
$Crep$	Repair costs	AU$
$Cfix$	Fixed costs	AU$
$opersc$	Other crew costs	AU$
$Cdep$	Depreciation costs	AU$

Table B.1: IAM variables and associated subscripts, continued

Variable	**Signification**	**Unit**
$Copport$	Opportunity cost of capital	AU$
$CvarUE$	Variable costs per unit effort	AU$.day^{-1}
GOS	Gross operating surplus	AU$
NOS	Net operating surplus	AU$
FTE	Full-time equivalent number of crew members	$\emptyset$
$Wage$	Wages	AU$
$Wage_{FTE}$	Wages per FTE	AU$
$NWage$	Net Wages	AU$
$\overline{F}_{targ}$	Fishing mortality target for the HCR	yr^{-1}
TAC	Total Allowable Catch	kg
Q	Individual quota	kg

B.1 Biological module

A stock is either modelled using annual age-based, or age- and sex-based dynamics, a surplus production model, or a static model which assumes that the total biomass of the stock remains constant.

Annual age-based dynamics are a simplified version of the age- and sex-based dynamics with only one gender. Both aim at incorporating stocks assessed with *Stock Synthesis 3 (SS3)* and use the equations provided in Methot and Wetzel [2013] given below.

Annual age- and sex-based dynamics are governed by:

$$\begin{aligned} N_{s,g,a+1,t+1} &= N_{s,g,a,t}\, e^{-Z_{s,g,a,t}} \quad a \in [A_{min}; A_{max}-1] \\ N_{s,g,A_{max},t+1} &= N_{s,g,A_{max}-1,t}\, e^{-Z_{s,g,A_{max}-1,t}} + N_{s,g,A_{max},t}\, e^{-Z_{s,g,A_{max},t}} \end{aligned} \tag{B.1}$$

where $N_{s,g,a,t}$ stands for the number of individuals from stock s of age a and gender g at time t, which experience a total mortality $Z_{s,g,a,t}$ equal to the sum of natural mortality $M_{s,g,a}$ and fishing mortality $F_{s,g,a,t}$. The fishing mortality applied to the stock is the sum of the fishing mortalities by vessel i and metier m ($F_{s,g,a,i,m,t}$) and the fishing mortality exerted by non-explicitly modelled fleets ($F_{s,g,a,t,OTH}$): $F_{s,g,a,t} = \sum_{i,m} F_{s,g,a,i,m,t} + F_{s,g,a,t,OTH}$. A_{min} (resp. A_{max}) is the age of the youngest (resp. oldest) modelled age class.

Fishing mortalities at age by vessel and metier ($F_{s,g,a,i,m,t}$) are proportional to individual fishing efforts by metier, assuming a constant catchability rate:

$$F_{s,g,a,i,m,t} = q_{s,g,a,i,m} \times E_{i,m,t}. \tag{B.2}$$

The spawning stock biomass of stock s at time t ($SSB_{s,t}$) is calculated as:

$$SSB_{s,t} = \sum_{a,g} Mat_{s,g,a} w_{s,g,a} N_{s,g,a,t} \tag{B.3}$$

with $Mat_{s,g,a}$ being the proportion of mature individuals of age a and gender g in stock s and $w_{s,a}$ their mean weight. $Mat_{s,g,a}$ for the non-spawning gender is equal to zero.

Recruitment can be modelled with Hockey-stick or Beverton-Holt stock recruitment relationships.

Beverton-Holt relationships calculate recruitment $N_{0,t}$ as follows:

$$N_{0,t} = \frac{4hR_0SSB_t}{SSB_0(1-h) + SSB_t(5h-1)} e^{\tilde{R}_t - \frac{\sigma_R^2}{2}} \quad \tilde{R}_t \sim N(\mu_R; \sigma_R^2), \tag{B.4}$$

with h the steepness parameter, R_0 the unfished equilibrium recruitment, SSB_0 the unfished equilibrium spawning biomass and R_t the deviation from the recruitment relationship drawn from a normal distribution of mean μ_R (representing recruitment shifts) and standard deviation σ_R^2. Bias in the estimation of the mean associated to the lognormal distribution is corrected by subtracting the factor $\frac{\sigma_R^2}{2}$ in the exponent [Methot and Taylor, 2011].

Recruitment using Hockey-Stick relationships is given by:

$$N_{0,t} = \begin{cases} a \times SSB \times e^{\tilde{R}_t} & \text{if } SSB < SSB^* \\ a \times SSB^* \times e^{\tilde{R}_t} & \text{if } SSB \geq SSB^* \end{cases}, \tag{B.5}$$

with a the slope of the curve, SSB^* the SSB at the breakpoint and R_t being drawn from a normal distribution of mean $-\frac{\sigma_R^2}{2}$ to account for bias in the lognormal distribution and standard deviation σ_R^2.

The surplus production model is that of Fox [1970] with the dynamics of stock biomass being governed by:

$$B_{s,t+1} = B_{s,t} \times (1 + r_s \times \ln(\frac{K_s}{B_{s,t}}) - F_{s,t}), \tag{B.6}$$

with $B_{s,t}$ being the biomass of stock s at time t, r_s its growth rate, K_s its carrying capacity, and $F_{s,t}$ the fishing mortality exerted on the stock at time t. Similarly to age-based dynamics, the fishing mortality is the sum of fishing mortalities exerted by modelled ($\sum_{i,m} F_{s,i,m,t}$) and non-modelled vessels ($F_{s,t,OTH}$): $F_{s,t} = \sum_{i,m} F_{s,i,m,t} + F_{s,t,OTH}$

B.2 Harvest Control Rule module

The management procedures module mimics the process of estimating each year the TAC for the following year so that the stock will be harvested at a fishing mortality rate $\overline{F}_{targ}$. It is a multi-step process:

1. Projection of :

   - the numbers at age ($N^*_{s,g,a,t+1}$) for year $t+1$ given a mean recruitment R_{mean} and equation B.1 for (sex- and) age-based dynamics.
   - the biomass ($B^*_{s,t+1}$) for year $t+1$ following equation B.6 for surplus production dynamics.

2. Calculation of current $\overline{F}$:

$$\overline{F}_{s,t} = \frac{1}{\sum_{g,a} p_{s,g,a}} \sum_{g,a} (p_{s,g,a} \times F_{s,g,a,t}) \tag{B.7}$$

   with $\delta_{g,a} = 1$ if age a of gender g is accounted for in the calculation of $\overline{F}$, and 0 otherwise

3. Calculation of fishing mortalities at age to reach $\overline{F}_{targ}$ (for (sex- and) age-based dynamics):

$$F_{targ_{s,g,a}} = F_{s,g,a,t} \times \frac{\overline{F}_{s,t}}{\overline{F}_{targ_s}} \tag{B.8}$$

4. Calculation of resulting landings using the equations from the catch module (Section B.5):

$$\begin{aligned} L^*_{s,t+1} &= \sum_{g,a} [(1 - d_{s,g,a}) w L_{s,g,a} \frac{F_{targ_{s,g,a}}}{F_{targ_{s,g,a}} + M_{s,g,a}} \\ &\times N^*_{s,g,a,t+1} \times (1 - e^{-F_{targ_{s,g,a}} + M_{s,g,a}})] \quad \text{for (sex-) and age-based dynamics} \\ &= (1 - d_s) \times \overline{F}_{targ_s} \times B^*_{s,t+1} \quad \text{for surplus production dynamics,} \end{aligned} \tag{B.9}$$

   which are used to set the TAC:

$$TAC_{s,t+1} = L^*_{s,t+1} \tag{B.10}$$

B.3 ITQ market module

This module simulates a walrassian tâtonnement process to determine market clearing lease prices for quota units. As summarized in Figure B.1, it builds on an iterative algorithm which progresses as follows:

1. Quota lease prices are given an initial value.[1]

   For each iteration *it* of the tâtonnement process:

[1] Quota lease prices are attributed a quasi-null value before entering the tâtonnement phase. The advantage of initiating quota prices at a null value is that at they will have to increase for markets to clear (at least for those who will clear given joint productions). However, given the form of the quota price adjustment function given in Equation B.15, one cannot start with a null value. Therefore, quota lease prices were initiated at 0.1% of the species ex-vessel price.

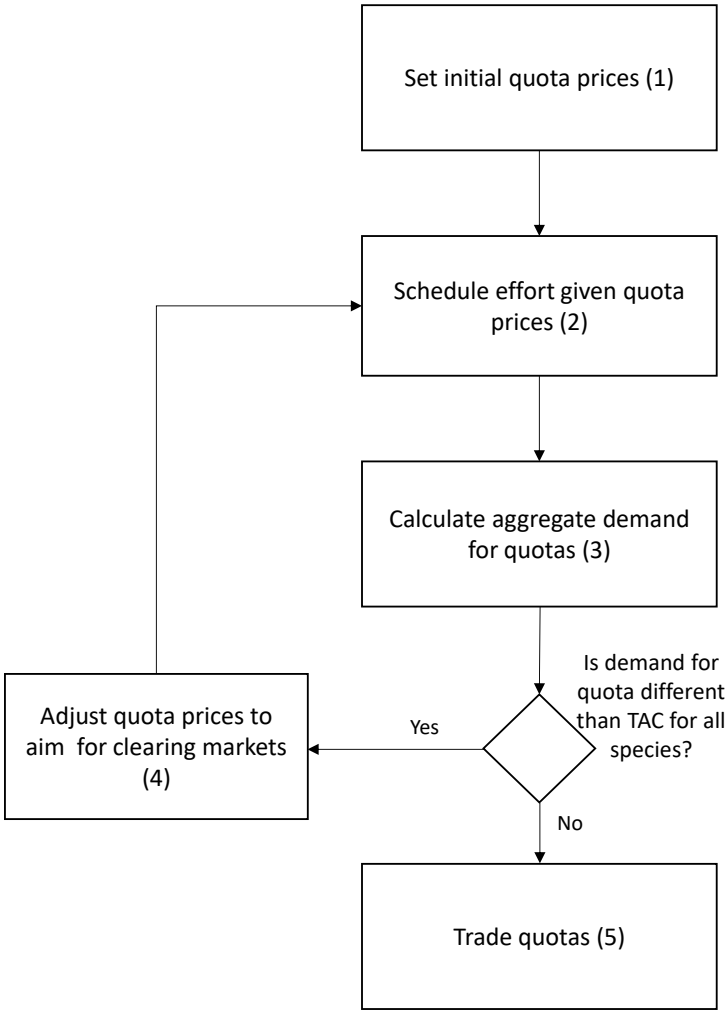

Figure B.1: Flowchart of the ITQ market module

2. Individual harvesters plan their fishing effort.

   - The allocation of annual fishing effort among metiers is modelled as a function of a weighted average of the metiers' expected profitability and past effort allocation (same function used in the short-term behaviour module as detail in Section B.4). The expected profitability of metier m for individual harvester i at time t and

iteration it ($ProfPUE^*_{i,m,t,it}$) is calculated as follows:

$$\begin{aligned} ProfPUE^*_{i,m,t,it} =& (1 - cshr_i) \times \sum_s (\frac{L_{s,i,m,t-1}}{E_{i,m,t-1}} \times p_{s,t-1}) \\ & - \sum_s (\frac{L_{s,i,m,t-1}}{E_{i,m,t-1}} \times \tilde{qp}_{s,t,it}) \\ & - CvarUE_{i,m,t-1} - \frac{Cfix_i + Cdep_i + Copport_i}{E_{i,t-1}}, \end{aligned} \tag{B.11}$$

if crews are remunerated as a share of the fishing income, and

$$\begin{aligned} ProfPUE^*_{i,m,t,it} =& (1 - cshr_i) \times (\sum_s (\frac{L_{s,i,m,t-1}}{E_{i,m,t-1}} \times p_{s,t-1}) - CvarUE_{i,m,t-1}) \\ & - \sum_s (\frac{L_{s,i,m,t-1}}{E_{i,m,t-1}} \times \tilde{qp}_{s,t,it}) \\ & - \frac{Cfix_i + Cdep_i + Copport_i}{E_{i,t-1}} \end{aligned} \tag{B.12}$$

if crews are remunerated as a share of the fishing income - variable costs (the "return to be shared").

$cshr_i$ represents the crew share of individual harvester i, $\frac{L_{s,i,m,t-1}}{E_{i,m,t-1}}$ the previous year's landings per unit of effort of species s by individual i in metier m, $p_{s,t-1}$ the ex-vessel price of species s in the previous year and $\tilde{qp}_{s,t,it}$ its lease price in the current iteration. $CvarUE_{i,m,t-1}$ represents the variable costs per unit of effort in the previous year for individual i in metier m, and $\frac{Cfix_i+Cdep_i+Copport_i}{E_{i,t-1}}$ the vessel's fixed and capital costs per unit of effort. Relative profitabilities $ProfPUE^*_c$ (i.e. centred on the profitability of the vessel's least profitable metier), are used in the effort allocation function to avoid negative coefficients: $ProfPUE^*_{c_{i,m,t,it}} = ProfPUE^*_{i,m,t,it} - \min_m(ProfPUE^*_{i,m,t,it})$

The proportion of effort individual harvester i plans to allocate to metier m at time t and iteration it, $pE^*_{i,m,t,it}$, is calculated as follows:

$$pE^*_{i,m,t,it} = \alpha \times \frac{ProfPUE^*_{c_{i,m,t,it}}}{\sum_m ProfPUE^*_{c_{i,m,t,it}}} + (1 - \alpha) \times \frac{E_{0_{i,m}}}{\sum_m E_{0_{i,m}}}, \tag{B.13}$$

with $E_{0_{i,m}}$ being the historical effort of individual harvester i allocated to metier m and α the weight given to profitability in the allocation of effort.

- Given the planned allocation of fishing effort, individual harvester i assesses whether it is profitable to go fishing. If the average profitability per unit of effort, $ProfPUE^*_{i,t,it} = \sum_m (pE^*_{i,m,t,it} \times ProfPUE^*_{i,m,t,it})$, is positive, then individual harvester i plans to operate at its maximum effort E_{max_i}. Otherwise, he decides to

remain at port:

$$E^*_{i,t,it} = \begin{cases} E_{max_i} & \text{if } ProfPUE^*_{i,t,it} > 0, \\ 0 & \text{otherwise.} \end{cases} \tag{B.14}$$

3. Once fishing efforts are set, the biological and catch modules are called to estimate individual demands for quota for all species (i.e. expected landings $L^*_{i,s,t,it}$).

4. Quota prices are then adjusted for the next iteration to aim for clearing quota lease markets:

$$\tilde{qp}_{s,t,it+1} = \tilde{qp}_{s,t,it} \times (1 - \lambda_q \times \frac{TAC_{s,t} - \sum_i L^*_{s,i,t,it}}{TAC_{s,t}}), \tag{B.15}$$

   with $TAC_{s,t}$ being the total allowable catch for species s at time t and λ_q a fixed multiplier.[2]

   Steps 2 to 4 are iterated until total demand for quota is close enough to the TAC for all species (i.e $\frac{TAC_{s,t} - \sum_i L^*_{s,i,t,it}}{TAC_{s,t}} < \epsilon$) or after it_{max} iterations. Let us note it_e the iteration at which the iterative process stops.

5. Once quota markets have reached equilibrium, quota prices are set at their equilibrium value ($qp_{s,t} = \tilde{qp}_{s,t,it_e}$) and quotas for all species are traded. In a multi-species context, all quota markets may not clear which requires the trading process to be explicitly modelled as all leasers may not find a buyer. Individual net demands for quota ($Demand$) are calculated by deducing initial quota holdings ($Holdings$) from expected catches at equilibrium (L^*):

$$Demand_{s,i,t} = Holdings_{s,i,t} - L^*_{s,i,t,it_e}. \tag{B.16}$$

   Similar to the approach proposed by Little et al. [2009], priority is given to trades between participants with the highest incentive to lease out or rent quota. The incentive to take part in a trade is measured by $\mid ProfPUE^*_{i,t,it_e} \mid$. For each species, quota leasers are ranked by decreasing order of profitability and quota lessors by increasing order of profitability. Trades are conducted by order of priority under the limit of what is available or needed, i.e $\min(-Demand_{s,lessor}, Demand_{s,leaser})$, and so until offer or demand expires. Some quota may also be hold by external investors which are grouped into an additional market participant. Currently, external investors are given priority in trades but this could easily be modified.

B.4 Short-term behaviour module

The short-term behaviour module determines fishing effort at the metier level for each individual harvester. It is a 2-step process:

[2]The value of the multiplier is determined empirically to achieve a satisfying compromise between the precision of convergence and computing time. Precision will be greater for low values of λ but at the cost of increased convergence time.

1. determination of the fishing strategy, i.e. the allocation of fishing effort among various metiers
2. reconciliation of effort against quota constraints on several species

The allocation of fishing effort among metiers at the individual level is modelled as a function of a weighted average between habit and expected profitability. At the beginning of each year, individual harvesters estimate the expected profitability of the metiers they practice ($ProfPUE^*$) based on the information available to them at the time, i.e. their past catch rates and costs but the current quota lease prices. At time t, the expected profitability $ProfPUE^*_{i,m,t}$ of metier m operated by individual i corresponds to its expected profits per unit of effort, namely:

$$\begin{aligned} ProfPUE^*_{i,m,t} =& (1 - cshr_i) \times \sum_s (\frac{L_{s,i,m,t-1}}{E_{i,m,t-1}} \times p_{s,t-1}) \\ & - \sum_s (\frac{L_{s,i,m,t-1}}{E_{i,m,t-1}} \times qp_{s,t}) \\ & - CvarUE_{i,m,t-1} - \frac{Cfix_i + Cdep_i + Copport_i}{E_{i,t-1}} \end{aligned} \tag{B.17}$$

if crews are remunerated as a share of the fishing income, and

$$\begin{aligned} ProfPUE^*_{i,m,t} =& (1 - cshr_i) \times (\sum_s (\frac{L_{s,i,m,t-1}}{E_{i,m,t-1}} \times p_{s,t-1}) - CvarUE_{i,m,t-1}) \\ & - \sum_s (\frac{L_{s,i,m,t-1}}{E_{i,m,t-1}} \times qp_{s,t}) \\ & - \frac{Cfix_i + Cdep_i + Copport_i}{E_{i,t-1}} \end{aligned} \tag{B.18}$$

if crews are remunerated as a share of the fishing income - variable costs (the "return to be shared").

$cshr_i$ represents the crew share of individual harvester i, $\frac{L_{s,i,m,t-1}}{E_{i,m,t-1}}$ the landings per unit of effort of species s by individual i in metier m in the previous year, $p_{s,t-1}$ the ex-vessel price of species s in the previous year and $qp_{s,t}$ its lease price estimated by the ITQ market module (Section B.3). $CvarUE_{i,m,t-1}$ represent the variable costs per unit of effort for individual i in metier m in the previous year, and $\frac{Cfix_i+Cdep_i+Copport_i}{E_{i,t-1}}$ the individual's fixed and capital costs (depreciation and opportunity) per unit of effort. Relative profitabilities $ProfPUE^*_c$ (i.e. centred on the profitability of the vessel's least profitable metier), are used in the effort allocation function to avoid negative coefficients: $ProfPUE^*_{c_{i,m,t}} = ProfPUE^*_{i,m,t} - \min_m(ProfPUE^*_{i,m,t})$

The proportion of effort $pE_{i,m,t}$ allocated by individual i to metier m at time t is then calculated as:

$$pE_{i,m,t} = \alpha \times \frac{ProfPUE^*_{c_{i,m,t}}}{\sum_m ProfPUE^*_{c_{i,m,t}}} + (1 - \alpha) \times \frac{E_{0_{i,m}}}{\sum_m E_{0_{i,m}}}, \tag{B.19}$$

with $E_{0_{i,m}}$ being the original effort of individual i allocated to metier m and α the weight given to profitability against habit when allocating effort.

In a second time, individual fishing efforts at the metier level ($E_{i,m,t}$) reconciling the various quota constraints are determined in a 2-step process:

1. Calculation of the effort $E_{i,m,s,t}$ required to catch the quota $Q_{i,s,t}$ for each individual harvester i, metier m and stock s. This formally write as:

$$\text{Find } \lambda_{i,s,t} \text{ such that } \begin{cases} \sum_m L_{i,m,s,t} = Q_{i,s,t}, \\ E_{i,m,s,t} = \lambda_{i,s,t} \times E_{i,t_0} \times pE_{i,m,t}. \end{cases} \tag{B.20}$$

   with $L_{i,m,s,t}$ the landings of stock s at time t by individual i in metier m as calculated by the catch module (Section B.5).

2. Effort reconciliation at the metier level so that each fisherman stops fishing with metier m either when its most constraining quota is exhausted or when he has reached the upper limit E_{max}, i.e.:

$$E_{i,m,t} = \min(E_{max_i} \times pE_{i,m,t}, \min_s E_{i,m,s,t}). \tag{B.21}$$

B.5 Catch module

Individual landings by metier for species with (sex- and) age-based dynamics are given by:

$$L_{i,m,s,g,a,t} = (1 - d_{s,g,a})\, wL_{s,g,a}\, \frac{F_{i,m,s,g,a,t}}{Z_{s,g,a,t}}\, N_{s,g,a,t}\, (1 - e^{-Z_{s,g,a,t}}), \tag{B.22}$$

with $d_{s,g,a}$ the proportion of discarded individuals of gender g, age a and stock s, and $wL_{s,g,a}$ the individual weight at age in the landings of stock s.

Landings of stocks modelled with a surplus production model are given by:

$$L_{i,m,s,t} = (1 - d_s) \times F_{i,m,s,t} \times B_{s,t} \tag{B.23}$$

Those for static stocks are given by:

$$L_{i,m,s,t} = LPUE_{i,m,s} \times E_{i,m,t}, \tag{B.24}$$

$LPUE_{i,m,s}$ being the landings of stock s per unit of effort for individual harvester i using metier m.

B.6 Economic module

This module calculates for each individual harvester i a variety of economic outputs, which are listed in Bellanger et al. [2018].

Supplementary Material C

Calibration of the IAM model for the Southern and Eastern Scalefish and Shark Fishery

C.1 Biological module

The list of represented stocks and associated population dynamics models is given in Table C.1.

Table C.2 provides the calibration of stock dynamics. Parameters for the stocks modelled with a global surplus production model were either retrieved from Pascoe et al. [2018] (School shark, gummy shark and mirror dory) or specially estimated for this work (Ocean perch, john dory and blue-eye trevalla). The later were carried out with the package *datalowSA* [Haddon, 2019] and using time series of catches from Castillo-Jordán et al. [2018] and catch rates from Sporcic and Haddon [2018]. Model parameters for the (sex- and) age-based dynamics were obtained from stock assessments carried out by CSIRO Oceans and Atmosphere using the statistical framework *Stock Synthesis (SS3)* [Methot and Wetzel, 2013]. References to those stock assessments are:

- School whiting: Day [2017],
- Silver warehou: Burch et al. [2018],
- Jackass morwong (East): Day and Castillo-Jordán [2018a],
- Jackass Morwong (West): Day and Castillo-Jordán [2018b],
- Tiger flathead: Day [2016],
- Blue grenadier: Castillo-Jordán and Tuck [2018],
- Pink ling (East): pers. com. Sandra Curin-Osorio,
- Pink ling (West): pers. com. Sandra Curin-Osorio,

Table C.1: Modelled stocks in the Southern and Eastern Scalefish and Shark Fishery

Stock	**Species**	**Quota**	**IAM dynamics**
Blue-eye trevalla	*Hyperoglyphe antarctica*	Yes	Surplus production
Blue grenadier	*Macruronus novaezelandiae*	Yes	Age- and sex-based
Blue warehou	*Seriolella brama*	Yes	Static
Deepwater sharks	complete list in Patterson et al. [2018]	Yes	Static
Eastern school whiting	*Sillago flindersi*	Yes	Age-based
Elephantfish	*Callorhinchus milii*	Yes	Static
Flathead	*Neoplatycephalus richardsoni* and 4 other species	Yes	Age- and Sex-based
Gemfish	*Rexea solandri*	Yes	Static
Gummy shark	*Mustelus antarcticus*	Yes	Surplus production
Jackass morwong (East)	*Nemadactylus macropterus*	Yes	Age-based
Jackass morwong (West)	*Nemadactylus macropterus*	Yes	Age-based
John dory	*Zeus faber*	Yes	Surplus production
Mirror dory	*Zenopsis nebulosa*	Yes	Surplus production
Ocean jacket	*Nelusetta ayraud*	No	Static
Ocean perch	*Helicolenus barathri, H. percoides*	Yes	Surplus production
Orange roughy (East)	*Hoplostethus atlanticus*	Yes	Age- and sex-based
Orange roughy (South)	*Hoplostethus atlanticus*	Yes	Static
Orange roughy (West)	*Hoplostethus atlanticus*	Yes	Static
Oreodories	complete list in Patterson et al. [2018]	Yes	Static
Pink ling (East)	*Genypterus blacodes*	Yes	Age- and sex-based
Pink ling (West)	*Genypterus blacodes*	Yes	Age- and sex-based
Redfish	*Centroberyx affinis*	Yes	Age- and sex-based
Ribaldo	*Mora moro*	Yes	Static
Royal red prawn	*Haliporoides sibogae*	Yes	Static
Sawshark	*Pristiophorus cirratus, P. nudipinnis*	Yes	Static
School shark	*Galeorhinus galeus*	Yes	Surplus production
Silver trevally	*Pseudocaranx georgianus*	Yes	Static
Silver warehou	*Seriolella punctata*	Yes	Age-based

- Redfish: Tuck et al. [2017],
- Orange roughy (East): Tuck et al. [2018].

Stock-specific reference points were also calculated from stock assessment outputs. For (sex- and) age-based stock assessments, F_{MSY} was determined by identifying the multiplier μ_s of the current vector of fishing mortality at age $F_{s,g,a,0}$ maximizing total yield at equilibrium

(which is the production of yield per recruit and recruitment, both being functions of fishing mortality): $F_{MSY_{s,g,a}} = \mu_s F_{s,g,a,0}$. A single F value for the stock was then estimated as a weighted mean of the values at age:

$$F_{MSY_s} = \frac{1}{nb_g \times \sum_a \delta_{s,a}} \sum_a (\sum_g (F_{MSY_{s,g,a}} \times \frac{N_{s,g,a}}{N_{s,a}}) \times \delta_{s,a}), \tag{C.1}$$

with $\delta_{s,a} = 1$ if age a is selected for the calculation and 0 otherwise. Youngest and oldest ages having very small contribution to the catch were removed from the selection, under the constraint of remaining ages accounting for at least 90% of the catch. Weighting coefficients $\delta_{s,a}$ are provided in Table C.2.

The same approach was followed to calculate the limit reference point F_{20} associated to an equilibrium spawning stock biomass equal to 20% of its virgin value.

For stocks represented with a global surplus production model, $F_{MSY_s} = r_s$ and $F_{20_s} = r_s \ln(\frac{1}{0.2})$.

Table C.2: Biological parameters

Stock	Initial biomass (t) B_{2015}	Growth rate (yr^{-1}) r	Carrying capacity (t) K	Initial fishing mortality (yr^{-1}) F_{2015}
Ocean Perch	926	0.69	1190	0.16
Mirror Dory	12849	0.61	13000	0.02
John Dory	1660	0.04	4270	0.04
School shark	6943	0.08	36000	0.03
Blue-eye trevalla	3687	0.08	12375	0.08
Gummy shark	13148	0.38	17369	0.15

Stock	Sex	Age a	Initial abundance $N_{a,2015}$ ($.10^3$)	Natural mortality M_a (yr^{-1})	Init. fish. mortality $F_{a,2015}$ (yr^{-1})	$\overline{F}$ weighting δ_a	Weight in stock w_a (kg/ind)	Weight in landings wl_a (kg/ind)	Maturity Mat_a
School Whiting	Both	0	245083	0.59	0.00	0	0.00	0.01	0.00
		1	134054	0.59	0.01	0	0.02	0.03	0.00
		2	71429	0.59	0.16	1	0.03	0.05	0.21
		3	32363	0.59	0.38	1	0.05	0.07	0.77
		4	10939	0.59	0.51	1	0.07	0.09	0.96
		5	4587	0.59	0.56	1	0.09	0.10	0.99
		6	1050	0.59	0.59	0	0.11	0.11	1.00
		7	345	0.59	0.60	0	0.12	0.12	1.00
		8	116	0.59	0.60	0	0.13	0.13	1.00
		9+	63	0.59	0.60	0	0.14	0.15	1.00
Silver warehou	Both	0	9032	0.30	0.00	0	0.01	0.03	0.00
		1	4381	0.30	0.00	0	0.04	0.15	0.00
		2	3781	0.30	0.02	1	0.23	0.38	0.00
		3	1086	0.30	0.04	1	0.52	0.74	0.02
		4	895	0.30	0.06	1	0.85	1.11	0.54
		5	924	0.30	0.08	1	1.18	1.42	0.90
		6	545	0.30	0.09	1	1.48	1.69	0.98
		7	176	0.30	0.10	1	1.73	1.90	0.99
		8	152	0.30	0.10	1	1.93	2.07	1.00
		9	196	0.30	0.11	1	2.09	2.21	1.00
		10	70	0.30	0.11	1	2.21	2.31	1.00
		11	74	0.30	0.11	1	2.30	2.39	1.00
		12	58	0.30	0.11	1	2.38	2.45	1.00
		13	68	0.30	0.11	1	2.43	2.50	1.00
		14	34	0.30	0.11	1	2.47	2.53	1.00
		15	18	0.30	0.11	1	2.50	2.56	1.00
		16	14	0.30	0.11	1	2.52	2.57	1.00
		17	3	0.30	0.11	0	2.54	2.59	1.00
		18	1	0.30	0.11	0	2.55	2.60	1.00
		19	1	0.30	0.11	0	2.56	2.61	1.00
		20	0	0.30	0.11	0	2.57	2.61	1.00
		21	1	0.30	0.11	0	2.57	2.62	1.00
		22	0	0.30	0.11	0	2.58	2.62	1.00
		23+	0	0.30	0.11	0	2.58	2.62	1.00

Stock	Sex	Age a	Initial abundance $N_{a,2015}$ ($.10^3$)	Natural mortality M_a (yr^{-1})	Init. fish. mortality $F_{a,2015}$ (yr^{-1})	$\overline{F}$ weighting δ_a	Weight in stock w_a (kg/ind)	Weight in landings wl_a (kg/ind)	Maturity Mat_a
Jackass morwong (West)	Both	0	1110	0.15	0.00	0	0.07	0.10	0.00
		1	930	0.15	0.00	0	0.10	0.15	0.01
		2	780	0.15	0.00	0	0.14	0.22	0.05
		3	851	0.15	0.00	1	0.20	0.33	0.24
		4	905	0.15	0.00	1	0.29	0.44	0.63
		5	765	0.15	0.00	1	0.38	0.53	0.85
		6	508	0.15	0.00	1	0.46	0.61	0.94
		7	348	0.15	0.01	1	0.54	0.67	0.97
		8	144	0.15	0.01	1	0.60	0.72	0.98
		9	142	0.15	0.01	1	0.65	0.76	0.99
		10	80	0.15	0.01	1	0.70	0.80	0.99
		11	74	0.15	0.01	1	0.73	0.83	1.00
		12	95	0.15	0.01	1	0.76	0.85	1.00
		13	71	0.15	0.01	1	0.79	0.87	1.00
		14	83	0.15	0.01	1	0.81	0.89	1.00
		15	53	0.15	0.01	1	0.82	0.90	1.00
		16	52	0.15	0.01	1	0.83	0.91	1.00
		17	16	0.15	0.01	1	0.84	0.92	1.00
		18	14	0.15	0.01	1	0.85	0.92	1.00
		19	6	0.15	0.01	0	0.86	0.93	1.00
		20	9	0.15	0.01	0	0.86	0.93	1.00
		21	6	0.15	0.01	0	0.87	0.93	1.00
		22	9	0.15	0.01	0	0.87	0.94	1.00
		23	6	0.15	0.01	0	0.87	0.94	1.00
		24	5	0.15	0.01	0	0.87	0.94	1.00
		25	2	0.15	0.01	0	0.88	0.94	1.00
		26	2	0.15	0.01	0	0.88	0.94	1.00
		27	2	0.15	0.01	0	0.88	0.94	1.00
		28	2	0.15	0.01	0	0.88	0.94	1.00
		29	1	0.15	0.01	0	0.88	0.94	1.00
		30+	7	0.15	0.01	0	0.88	0.94	1.00
Jackass morwong (East)	Both	0	2342	0.15	0.00	0	0.07	0.11	0.00
		1	1978	0.15	0.00	0	0.10	0.16	0.01
		2	1702	0.15	0.00	1	0.14	0.23	0.05
		3	1343	0.15	0.01	1	0.20	0.31	0.24
		4	944	0.15	0.03	1	0.29	0.40	0.63
		5	947	0.15	0.04	1	0.38	0.48	0.85
		6	585	0.15	0.05	1	0.46	0.55	0.94
		7	338	0.15	0.06	1	0.54	0.61	0.97
		8	178	0.15	0.06	1	0.60	0.66	0.98
		9	183	0.15	0.06	1	0.65	0.71	0.99
		10	104	0.15	0.07	1	0.70	0.75	0.99
		11	116	0.15	0.07	1	0.73	0.78	1.00
		12	144	0.15	0.07	1	0.76	0.80	1.00
		13	114	0.15	0.07	1	0.79	0.82	1.00
		14	100	0.15	0.07	1	0.81	0.84	1.00
		15	28	0.15	0.07	1	0.82	0.85	1.00
		16	25	0.15	0.07	1	0.83	0.86	1.00
		17	16	0.15	0.07	1	0.84	0.87	1.00
		18	16	0.15	0.07	1	0.85	0.87	1.00
		19	4	0.15	0.07	0	0.86	0.88	1.00
		20	3	0.15	0.07	0	0.86	0.88	1.00
		21	7	0.15	0.07	0	0.87	0.89	1.00
		22	6	0.15	0.07	0	0.87	0.89	1.00
		23	4	0.15	0.07	0	0.87	0.89	1.00
		24	3	0.15	0.07	0	0.87	0.89	1.00
		25	2	0.15	0.07	0	0.88	0.89	1.00
		26	1	0.15	0.07	0	0.88	0.90	1.00

Stock	Sex	Age	Initial abundance	Natural mortality	Init. fish. mortality	$\overline{F}$ weighting	Weight in stock	Weight in landings	Maturity
		a	$N_{a,2015}$ $(.10^3)$	M_a (yr^{-1})	$F_{a,2015}$ (yr^{-1})	δ_a	w_a (kg/ind)	wl_a (kg/ind)	Mat_a
		27	1	0.15	0.07	0	0.88	0.90	1.00
		28	1	0.15	0.07	0	0.88	0.90	1.00
		29	1	0.15	0.07	0	0.88	0.90	1.00
		30+	2	0.15	0.07	0	0.88	0.90	1.00

Stock	Sex	Age a	Initial abundance $N_{a,2015}$ ($.10^3$)	Natural mortality M_a (yr^{-1})	Init. fish. mortality $F_{a,2015}$ (yr^{-1})	$\overline{F}$ weighting δ_a	Weight in stock w_a (kg/ind)	Weight in landings wl_a (kg/ind)	Maturity Mat_a
Flathead	Female	0	8612	0.27	0.00	0	0.00	0.01	0.00
		1	6436	0.27	0.00	0	0.03	0.10	0.00
		2	4735	0.27	0.03	0	0.16	0.38	0.00
		3	4898	0.27	0.10	1	0.48	0.69	0.57
		4	3453	0.27	0.14	1	0.73	0.93	0.76
		5	2573	0.27	0.17	1	0.99	1.20	0.87
		6	958	0.27	0.18	1	1.26	1.48	0.92
		7	1001	0.27	0.20	1	1.53	1.76	0.95
		8	367	0.27	0.21	1	1.79	2.04	0.97
		9	203	0.27	0.23	1	2.02	2.29	0.98
		10	91	0.27	0.24	1	2.24	2.52	0.98
		11	49	0.27	0.25	1	2.42	2.70	0.99
		12	95	0.27	0.26	1	2.58	2.86	0.99
		13	21	0.27	0.27	0	2.72	2.99	0.99
		14	12	0.27	0.28	0	2.83	3.09	0.99
		15	9	0.27	0.29	0	2.93	3.18	0.99
		16	8	0.27	0.30	0	3.00	3.25	0.99
		17	6	0.27	0.30	0	3.07	3.30	1.00
		18	2	0.27	0.30	0	3.12	3.35	1.00
		19	1	0.27	0.31	0	3.17	3.38	1.00
		20+	1	0.27	0.31	0	3.24	3.45	1.00
	Male	0	8612	0.27	0.00	0	0.00	0.01	0.00
		1	6436	0.27	0.00	0	0.03	0.08	0.00
		2	4738	0.27	0.02	0	0.14	0.31	0.00
		3	4954	0.27	0.08	1	0.39	0.57	0.00
		4	3589	0.27	0.11	1	0.56	0.73	0.00
		5	2767	0.27	0.14	1	0.72	0.88	0.00
		6	1071	0.27	0.15	1	0.88	1.03	0.00
		7	1161	0.27	0.17	1	1.03	1.16	0.00
		8	442	0.27	0.17	1	1.16	1.29	0.00
		9	254	0.27	0.18	1	1.28	1.40	0.00
		10	118	0.27	0.19	1	1.38	1.50	0.00
		11	67	0.27	0.19	1	1.47	1.59	0.00
		12	134	0.27	0.19	1	1.55	1.67	0.00
		13	31	0.27	0.20	0	1.61	1.73	0.00
		14	18	0.27	0.20	0	1.66	1.79	0.00
		15	15	0.27	0.20	0	1.71	1.83	0.00
		16	15	0.27	0.20	0	1.74	1.87	0.00
		17	11	0.27	0.21	0	1.77	1.90	0.00
		18	4	0.27	0.21	0	1.80	1.93	0.00
		19	1	0.27	0.21	0	1.82	1.95	0.00
		20+	3	0.27	0.21	0	1.86	1.98	0.00

Stock	Sex	Age a	Initial abundance $N_{a,2015}$ $(.10^3)$	Natural mortality M_a (yr^{-1})	Init. fish. mortality $F_{a,2015}$ (yr^{-1})	$\overline{F}$ weighting δ_a	Weight in stock w_a (kg/ind)	Weight in landings wl_a (kg/ind)	Maturity Mat_a
Blue grenadier	Female	0	7233	0.17	0.00	0	0.19	0.19	0.00
		1	17581	0.17	0.00	0	0.19	0.27	0.00
		2	22545	0.17	0.01	1	0.33	0.55	0.00
		3	15464	0.17	0.02	1	0.60	0.80	0.04
		4	14231	0.17	0.02	1	0.95	1.14	0.22
		5	8325	0.17	0.02	1	1.39	1.61	0.55
		6	1576	0.17	0.02	1	2.01	2.21	0.77
		7	212	0.17	0.02	1	2.37	2.52	0.81
		8	288	0.17	0.02	1	3.23	3.33	0.84
		9	492	0.17	0.02	1	3.51	3.59	0.84
		10	73	0.17	0.02	1	3.41	3.48	0.84
		11	225	0.17	0.02	1	3.88	3.92	0.84
		12	1319	0.17	0.02	1	3.81	3.85	0.84
		13	45	0.17	0.02	0	3.85	3.89	0.84
		14	32	0.17	0.02	0	3.91	3.94	0.84
		15	9	0.17	0.02	0	3.92	3.95	0.84
		16	10	0.17	0.02	0	4.20	4.21	0.84
		17	13	0.17	0.02	0	4.20	4.21	0.84
		18	47	0.17	0.02	0	4.22	4.23	0.84
		19	76	0.17	0.02	0	4.22	4.23	0.84
		20+	1278	0.17	0.02	0	4.15	4.16	0.84
	Male	0	7233	0.21	0.00	0	0.18	0.18	0.00
		1	16979	0.21	0.00	0	0.18	0.28	0.00
		2	21026	0.21	0.01	1	0.31	0.51	0.00
		3	13938	0.21	0.02	1	0.54	0.71	0.00
		4	12391	0.21	0.02	1	0.82	0.99	0.00
		5	6975	0.21	0.02	1	1.16	1.34	0.00
		6	1242	0.21	0.03	1	1.60	1.75	0.00
		7	156	0.21	0.03	1	1.84	1.95	0.00
		8	193	0.21	0.03	1	2.37	2.39	0.00
		9	315	0.21	0.03	1	2.52	2.51	0.00
		10	45	0.21	0.03	1	2.47	2.46	0.00
		11	134	0.21	0.02	1	2.70	2.67	0.00
		12	750	0.21	0.03	1	2.67	2.63	0.00
		13	24	0.21	0.03	0	2.68	2.65	0.00
		14	17	0.21	0.02	0	2.71	2.67	0.00
		15	5	0.21	0.02	0	2.72	2.68	0.00
		16	5	0.21	0.02	0	2.84	2.79	0.00
		17	6	0.21	0.02	0	2.84	2.79	0.00
		18	20	0.21	0.02	0	2.84	2.79	0.00
		19	30	0.21	0.02	0	2.84	2.79	0.00
		20+	452	0.21	0.02	0	2.81	2.76	0.00

Stock	Sex	Age a	Initial abundance $N_{a,2015}$ ($.10^3$)	Natural mortality M_a (yr^{-1})	Init. fish. mortality $F_{a,2015}$ (yr^{-1})	$\overline{F}$ weighting δ_a	Weight in stock w_a (kg/ind)	Weight in landings wl_a (kg/ind)	Maturity Mat_a
Pink ling (East)	Female	0	698	0.20	0.00	0	0.01	0.03	0.00
		1	420	0.20	0.00	0	0.07	0.29	0.00
		2	210	0.20	0.03	1	0.32	0.81	0.00
		3	227	0.20	0.10	1	0.87	1.27	0.03
		4	185	0.20	0.12	1	1.42	1.70	0.27
		5	131	0.20	0.11	1	2.04	2.18	0.63
		6	87	0.20	0.09	1	2.69	2.75	0.86
		7	56	0.20	0.08	1	3.34	3.40	0.96
		8	55	0.20	0.07	1	3.98	4.09	0.99
		9	41	0.20	0.06	1	4.58	4.74	1.00
		10	18	0.20	0.06	1	5.14	5.33	1.00
		11	21	0.20	0.06	1	5.65	5.85	1.00
		12	18	0.20	0.06	1	6.11	6.30	1.00
		13	9	0.20	0.06	1	6.53	6.70	1.00
		14	6	0.20	0.06	1	6.90	7.05	1.00
		15	3	0.20	0.06	1	7.22	7.36	1.00
		16	3	0.20	0.06	1	7.50	7.63	1.00
		17	2	0.20	0.06	0	7.75	7.86	1.00
		18	1	0.20	0.06	0	7.97	8.06	1.00
		19	2	0.20	0.06	0	8.15	8.24	1.00
		20	1	0.20	0.06	0	8.31	8.39	1.00
		21	1	0.20	0.06	0	8.45	8.52	1.00
		22	0	0.20	0.06	0	8.57	8.63	1.00
		23	1	0.20	0.06	0	8.68	8.72	1.00
		24	0	0.20	0.06	0	8.77	8.80	1.00
		25	0	0.20	0.06	0	8.84	8.88	1.00
		26	0	0.20	0.06	0	8.91	8.94	1.00
		27	0	0.20	0.06	0	8.96	8.99	1.00
		28	0	0.20	0.06	0	9.01	9.03	1.00
		29	0	0.20	0.06	0	9.05	9.07	1.00
		30+	0	0.20	0.06	0	9.11	9.13	1.00
	Male	0	698	0.20	0.00	0	0.01	0.03	0.00
		1	420	0.20	0.00	0	0.07	0.27	0.00
		2	210	0.20	0.03	1	0.29	0.78	0.00
		3	229	0.20	0.10	1	0.79	1.21	0.00
		4	188	0.20	0.12	1	1.33	1.61	0.00
		5	133	0.20	0.12	1	1.87	2.01	0.00
		6	88	0.20	0.10	1	2.36	2.41	0.00
		7	56	0.20	0.09	1	2.79	2.79	0.00
		8	54	0.20	0.08	1	3.14	3.13	0.00
		9	39	0.20	0.07	1	3.43	3.41	0.00
		10	17	0.20	0.07	1	3.66	3.63	0.00
		11	20	0.20	0.07	1	3.83	3.81	0.00
		12	17	0.20	0.07	1	3.97	3.94	0.00
		13	8	0.20	0.06	1	4.08	4.04	0.00
		14	5	0.20	0.06	1	4.16	4.12	0.00
		15	3	0.20	0.06	1	4.22	4.18	0.00
		16	3	0.20	0.06	1	4.27	4.23	0.00
		17	2	0.20	0.06	0	4.30	4.26	0.00
		18	1	0.20	0.06	0	4.33	4.29	0.00
		19	2	0.20	0.06	0	4.35	4.30	0.00
		20	1	0.20	0.06	0	4.36	4.32	0.00
		21	1	0.20	0.06	0	4.38	4.33	0.00
		22	0	0.20	0.06	0	4.38	4.34	0.00
		23	1	0.20	0.06	0	4.39	4.34	0.00
		24	0	0.20	0.06	0	4.40	4.35	0.00
		25	0	0.20	0.06	0	4.40	4.35	0.00
		26	0	0.20	0.06	0	4.40	4.36	0.00
		27	0	0.20	0.06	0	4.40	4.36	0.00

Stock	Sex	Age	Initial abundance	Natural mortality	Init. fish. mortality	$\overline{F}$ weighting	Weight in stock	Weight in landings	Maturity
		a	$N_{a,2015}$ $(.10^3)$	M_a (yr^{-1})	$F_{a,2015}$ (yr^{-1})	δ_a	w_a (kg/ind)	wl_a (kg/ind)	Mat_a
		28	0	0.20	0.06	0	4.41	4.36	0.00
		29	0	0.20	0.06	0	4.41	4.36	0.00
		30+	0	0.20	0.06	0	4.41	4.36	0.00

Stock	Sex	Age a	Initial abundance $N_{a,2015}$ ($.10^3$)	Natural mortality M_a (yr^{-1})	Init. fish. mortality $F_{a,2015}$ (yr^{-1})	$\overline{F}$ weighting δ_a	Weight in stock w_a (kg/ind)	Weight in landings wl_a (kg/ind)	Maturity Mat_a
Pink ling (West)	Female	0	2309	0.29	0.00	0	0.01	0.03	0.00
		1	2122	0.29	0.00	0	0.08	0.22	0.00
		2	1195	0.29	0.00	1	0.34	0.70	0.00
		3	1250	0.29	0.02	1	0.93	1.30	0.00
		4	803	0.29	0.02	1	1.40	1.81	0.16
		5	544	0.29	0.03	1	1.92	2.38	0.54
		6	329	0.29	0.04	1	2.47	2.99	0.82
		7	232	0.29	0.05	1	3.02	3.56	0.93
		8	157	0.29	0.05	1	3.55	4.09	0.97
		9	97	0.29	0.06	1	4.07	4.57	0.99
		10	67	0.29	0.06	1	4.55	5.01	0.99
		11	57	0.29	0.06	1	5.00	5.41	1.00
		12	42	0.29	0.07	1	5.42	5.78	1.00
		13	20	0.29	0.07	1	5.79	6.11	1.00
		14	13	0.29	0.07	1	6.13	6.41	1.00
		15	7	0.29	0.07	1	6.44	6.67	1.00
		16	3	0.29	0.07	1	6.71	6.91	1.00
		17	3	0.29	0.07	1	6.95	7.11	1.00
		18	2	0.29	0.07	0	7.16	7.30	1.00
		19	1	0.29	0.07	0	7.35	7.46	1.00
		20	2	0.29	0.07	0	7.52	7.60	1.00
		21	1	0.29	0.07	0	7.66	7.73	1.00
		22	1	0.29	0.07	0	7.79	7.84	1.00
		23	1	0.29	0.07	0	7.90	7.93	1.00
		24	1	0.29	0.07	0	7.99	8.01	1.00
		25	0	0.29	0.07	0	8.08	8.09	1.00
		26	0	0.29	0.07	0	8.15	8.15	1.00
		27	0	0.29	0.07	0	8.22	8.20	1.00
		28	0	0.29	0.07	0	8.27	8.25	1.00
		29	0	0.29	0.07	0	8.32	8.29	1.00
		30+	0	0.29	0.07	0	8.40	8.36	1.00
	Male	0	2309	0.29	0.00	0	0.01	0.03	0.00
		1	2122	0.29	0.00	0	0.07	0.21	0.00
		2	1195	0.29	0.00	1	0.30	0.64	0.00
		3	1252	0.29	0.01	1	0.81	1.19	0.00
		4	806	0.29	0.02	1	1.27	1.65	0.00
		5	549	0.29	0.03	1	1.74	2.12	0.00
		6	334	0.29	0.03	1	2.19	2.57	0.00
		7	237	0.29	0.04	1	2.60	2.98	0.00
		8	161	0.29	0.05	1	2.97	3.33	0.00
		9	101	0.29	0.05	1	3.28	3.61	0.00
		10	70	0.29	0.05	1	3.55	3.85	0.00
		11	60	0.29	0.06	1	3.77	4.04	0.00
		12	45	0.29	0.06	1	3.96	4.20	0.00
		13	22	0.29	0.06	1	4.11	4.33	0.00
		14	14	0.29	0.06	1	4.24	4.44	0.00
		15	8	0.29	0.06	1	4.34	4.53	0.00
		16	4	0.29	0.06	1	4.42	4.59	0.00
		17	3	0.29	0.06	1	4.49	4.65	0.00
		18	2	0.29	0.06	0	4.54	4.70	0.00
		19	2	0.29	0.06	0	4.58	4.73	0.00
		20	2	0.29	0.06	0	4.62	4.76	0.00
		21	2	0.29	0.06	0	4.64	4.78	0.00
		22	1	0.29	0.06	0	4.67	4.80	0.00
		23	1	0.29	0.06	0	4.68	4.82	0.00
		24	1	0.29	0.06	0	4.70	4.83	0.00
		25	0	0.29	0.06	0	4.71	4.84	0.00
		26	0	0.29	0.06	0	4.72	4.85	0.00
		27	0	0.29	0.06	0	4.73	4.85	0.00

Stock	Sex	Age	Initial abundance	Natural mortality	Init. fish. mortality	$\overline{F}$ weighting	Weight in stock	Weight in landings	Maturity
		a	$N_{a,2015}$ $(.10^3)$	M_a (yr^{-1})	$F_{a,2015}$ (yr^{-1})	δ_a	w_a (kg/ind)	wl_a (kg/ind)	Mat_a
		28	0	0.29	0.06	0	4.73	4.86	0.00
		29	0	0.29	0.06	0	4.74	4.86	0.00
		30+	0	0.29	0.06	0	4.74	4.87	0.00

Stock	Sex	Age a	Initial abundance $N_{a,2015}$ ($.10^3$)	Natural mortality M_a (yr^{-1})	Init. fish. mortality $F_{a,2015}$ (yr^{-1})	$\overline{F}$ weighting δ_a	Weight in stock w_a (kg/ind)	Weight in landings wl_a (kg/ind)	Maturity Mat_a
Redfish	Female	0	6678	0.10	0.00	0	0.00	0.00	0.00
		1	6033	0.10	0.02	1	0.00	0.01	0.00
		2	26621	0.10	0.04	1	0.01	0.01	0.05
		3	14499	0.10	0.05	1	0.01	0.02	0.29
		4	3868	0.10	0.05	1	0.02	0.02	0.56
		5	1846	0.10	0.06	1	0.02	0.02	0.73
		6	1712	0.10	0.06	1	0.02	0.02	0.82
		7	3663	0.10	0.06	1	0.03	0.03	0.88
		8	1596	0.10	0.06	1	0.03	0.03	0.91
		9	764	0.10	0.06	1	0.03	0.03	0.92
		10	649	0.10	0.06	1	0.03	0.03	0.93
		11	591	0.10	0.06	1	0.03	0.03	0.94
		12	524	0.10	0.06	1	0.03	0.03	0.94
		13	916	0.10	0.06	1	0.03	0.03	0.95
		14	1147	0.10	0.06	1	0.03	0.03	0.95
		15	880	0.10	0.06	1	0.03	0.03	0.95
		16	570	0.10	0.06	1	0.03	0.03	0.95
		17	161	0.10	0.06	1	0.03	0.04	0.95
		18	69	0.10	0.06	0	0.03	0.04	0.95
		19	68	0.10	0.06	0	0.04	0.04	0.95
		20	62	0.10	0.06	0	0.04	0.04	0.95
		21	96	0.10	0.06	0	0.04	0.04	0.95
		22	82	0.10	0.06	0	0.04	0.04	0.95
		23	83	0.10	0.06	0	0.04	0.04	0.95
		24	36	0.10	0.06	0	0.04	0.04	0.95
		25	20	0.10	0.06	0	0.04	0.04	0.95
		26	10	0.10	0.06	0	0.04	0.04	0.95
		27	7	0.10	0.06	0	0.04	0.04	0.95
		28	6	0.10	0.06	0	0.04	0.04	0.95
		29	3	0.10	0.06	0	0.04	0.04	0.95
		30	3	0.10	0.06	0	0.04	0.04	0.95
		31	2	0.10	0.06	0	0.04	0.04	0.95
		32	2	0.10	0.06	0	0.04	0.04	0.95
		33	1	0.10	0.06	0	0.04	0.04	0.95
		34	1	0.10	0.06	0	0.04	0.04	0.95
		35	1	0.10	0.06	0	0.04	0.04	0.95
		36	1	0.10	0.06	0	0.04	0.04	0.95
		37	1	0.10	0.06	0	0.04	0.04	0.95
		38	0	0.10	0.06	0	0.04	0.04	0.95
		39+	2	0.10	0.06	0	0.04	0.04	0.95
	Male	0	6678	0.10	0.00	0	0.00	0.00	0.00
		1	6034	0.10	0.02	1	0.00	0.01	0.00
		2	26727	0.10	0.03	1	0.01	0.01	0.00
		3	14656	0.10	0.05	1	0.01	0.01	0.00
		4	3933	0.10	0.05	1	0.01	0.02	0.00
		5	1887	0.10	0.05	1	0.02	0.02	0.00
		6	1763	0.10	0.06	1	0.02	0.02	0.00
		7	3807	0.10	0.06	1	0.02	0.02	0.00
		8	1672	0.10	0.06	1	0.02	0.02	0.00
		9	805	0.10	0.06	1	0.02	0.02	0.00
		10	689	0.10	0.06	1	0.02	0.03	0.00
		11	634	0.10	0.06	1	0.03	0.03	0.00
		12	569	0.10	0.06	1	0.03	0.03	0.00
		13	1003	0.10	0.06	1	0.03	0.03	0.00
		14	1271	0.10	0.06	1	0.03	0.03	0.00
		15	985	0.10	0.06	1	0.03	0.03	0.00
		16	642	0.10	0.06	1	0.03	0.03	0.00
		17	183	0.10	0.06	1	0.03	0.03	0.00
		18	79	0.10	0.06	0	0.03	0.03	0.00

Stock	Sex	Age a	Initial abundance $N_{a,2015}$ ($.10^3$)	Natural mortality M_a (yr^{-1})	Init. fish. mortality $F_{a,2015}$ (yr^{-1})	$\overline{F}$ weighting δ_a	Weight in stock w_a (kg/ind)	Weight in landings wl_a (kg/ind)	Maturity Mat_a
		19	79	0.10	0.06	0	0.03	0.03	0.00
		20	71	0.10	0.06	0	0.03	0.03	0.00
		21	110	0.10	0.06	0	0.03	0.03	0.00
		22	95	0.10	0.06	0	0.03	0.03	0.00
		23	95	0.10	0.06	0	0.03	0.03	0.00
		24	42	0.10	0.06	0	0.03	0.03	0.00
		25	23	0.10	0.06	0	0.03	0.03	0.00
		26	12	0.10	0.06	0	0.03	0.03	0.00
		27	8	0.10	0.06	0	0.03	0.03	0.00
		28	7	0.10	0.06	0	0.03	0.03	0.00
		29	4	0.10	0.06	0	0.03	0.03	0.00
		30	3	0.10	0.06	0	0.03	0.03	0.00
		31	3	0.10	0.06	0	0.03	0.03	0.00
		32	2	0.10	0.06	0	0.03	0.03	0.00
		33	1	0.10	0.06	0	0.03	0.03	0.00
		34	1	0.10	0.06	0	0.03	0.03	0.00
		35	1	0.10	0.06	0	0.03	0.03	0.00
		36	1	0.10	0.06	0	0.03	0.03	0.00
		37	1	0.10	0.06	0	0.03	0.03	0.00
		38	1	0.10	0.06	0	0.03	0.03	0.00
		39+	2	0.10	0.06	0	0.03	0.03	0.00
Orange roughy (East)	Female	0	3642	0.04	0.00	0	0.02	0.03	0.00
		1	3446	0.04	0.00	0	0.04	0.05	0.00
		2	3256	0.04	0.00	0	0.06	0.09	0.00
		3	3072	0.04	0.00	0	0.08	0.20	0.00
		4	2893	0.04	0.00	0	0.11	0.27	0.00
		5	2719	0.04	0.00	0	0.15	0.36	0.00
		6	2550	0.04	0.00	0	0.19	0.47	0.00
		7	2386	0.04	0.00	0	0.23	0.59	0.00
		8	2235	0.04	0.00	0	0.27	0.72	0.00
		9	2099	0.04	0.00	0	0.32	0.86	0.00
		10	1974	0.04	0.00	0	0.36	1.00	0.00
		11	1858	0.04	0.00	0	0.41	1.13	0.00
		12	1764	0.04	0.00	0	0.46	1.22	0.00
		13	1694	0.04	0.00	0	0.51	1.28	0.00
		14	1639	0.04	0.00	0	0.57	1.32	0.00
		15	1590	0.04	0.00	0	0.62	1.35	0.00
		16	1546	0.04	0.00	0	0.67	1.38	0.00
		17	1509	0.04	0.00	0	0.72	1.40	0.00
		18	1476	0.04	0.00	0	0.77	1.42	0.01
		19	1449	0.04	0.00	0	0.82	1.43	0.01
		20	1439	0.04	0.00	1	0.86	1.45	0.03
		21	1468	0.04	0.00	1	0.91	1.47	0.04
		22	1559	0.04	0.00	1	0.95	1.48	0.06
		23	1619	0.04	0.00	1	1.00	1.50	0.09
		24	1627	0.04	0.00	1	1.04	1.51	0.12
		25	1611	0.04	0.00	1	1.08	1.52	0.16
		26	1563	0.04	0.00	1	1.12	1.54	0.20
		27	1502	0.04	0.00	1	1.16	1.55	0.24
		28	1443	0.04	0.00	1	1.20	1.57	0.28
		29	1384	0.04	0.00	1	1.23	1.58	0.32
		30	1327	0.04	0.01	1	1.27	1.60	0.36
		31	1340	0.04	0.01	1	1.30	1.61	0.40
		32	1251	0.04	0.01	1	1.33	1.63	0.44
		33	1123	0.04	0.01	1	1.36	1.64	0.47
		34	982	0.04	0.01	1	1.39	1.65	0.51
		35	839	0.04	0.01	1	1.42	1.67	0.54
		36	728	0.04	0.01	1	1.44	1.68	0.56

Stock	Sex	Age a	Initial abundance $N_{a,2015}$ ($.10^3$)	Natural mortality M_a (yr^{-1})	Init. fish. mortality $F_{a,2015}$ (yr^{-1})	$\overline{F}$ weighting δ_a	Weight in stock w_a (kg/ind)	Weight in landings wl_a (kg/ind)	Maturity Mat_a
		37	640	0.04	0.01	1	1.47	1.69	0.59
		38	570	0.04	0.01	1	1.49	1.71	0.62
		39	513	0.04	0.01	1	1.51	1.72	0.64
		40	462	0.04	0.01	1	1.53	1.73	0.66
		41	411	0.04	0.01	1	1.55	1.74	0.68
		42	358	0.04	0.01	1	1.57	1.75	0.69
		43	306	0.04	0.01	1	1.59	1.76	0.71
		44	259	0.04	0.01	1	1.61	1.78	0.72
		45	217	0.04	0.01	1	1.63	1.79	0.74
		46	182	0.04	0.01	1	1.64	1.80	0.75
Orange		47	153	0.04	0.01	1	1.66	1.80	0.76
roughy		48	128	0.04	0.01	1	1.67	1.81	0.77
(East)		49	108	0.04	0.01	1	1.68	1.82	0.78
		50	92	0.04	0.01	1	1.70	1.83	0.79
		51	78	0.04	0.01	1	1.71	1.84	0.80
		52	66	0.04	0.01	1	1.72	1.85	0.80
		53	57	0.04	0.01	1	1.73	1.85	0.81
		54	49	0.04	0.01	1	1.74	1.86	0.81
		55	42	0.04	0.01	1	1.75	1.87	0.82
		56	37	0.04	0.01	1	1.76	1.87	0.83
		57	33	0.04	0.01	1	1.77	1.88	0.83
		58	29	0.04	0.01	1	1.77	1.88	0.83
		59	27	0.04	0.01	1	1.78	1.89	0.84
		60	24	0.04	0.01	1	1.79	1.89	0.84
		61	23	0.04	0.01	1	1.80	1.90	0.85
		62	21	0.04	0.01	1	1.80	1.90	0.85
		63	20	0.04	0.01	1	1.81	1.91	0.85
		64	19	0.04	0.01	1	1.81	1.91	0.85
		65	18	0.04	0.01	1	1.82	1.92	0.86
		66	16	0.04	0.01	1	1.82	1.92	0.86
		67	15	0.04	0.01	1	1.83	1.92	0.86
		68	14	0.04	0.01	1	1.83	1.93	0.86
		69	13	0.04	0.01	1	1.84	1.93	0.86
		70	12	0.04	0.01	1	1.84	1.93	0.87
		71	11	0.04	0.01	1	1.85	1.94	0.87
		72	11	0.04	0.01	1	1.85	1.94	0.87
		73	10	0.04	0.01	1	1.85	1.94	0.87
		74	10	0.04	0.01	1	1.86	1.94	0.87
		75	9	0.04	0.01	1	1.86	1.95	0.87
		76	9	0.04	0.01	1	1.86	1.95	0.87
		77	8	0.04	0.01	1	1.86	1.95	0.88
		78	8	0.04	0.01	1	1.87	1.95	0.88
		79+	121	0.04	0.01	1	1.87	1.95	0.88
	Male	0	3642	0.04	0.00	0	0.02	0.03	0.00
		1	3446	0.04	0.00	0	0.04	0.05	0.00
		2	3256	0.04	0.00	0	0.06	0.09	0.00
		3	3072	0.04	0.00	0	0.09	0.20	0.00
		4	2893	0.04	0.00	0	0.12	0.27	0.00
		5	2719	0.04	0.00	0	0.15	0.36	0.00
		6	2550	0.04	0.00	0	0.19	0.47	0.00
		7	2386	0.04	0.00	0	0.23	0.58	0.00
		8	2235	0.04	0.00	0	0.27	0.71	0.00
		9	2099	0.04	0.00	0	0.32	0.85	0.00
		10	1974	0.04	0.00	0	0.36	0.99	0.00
		11	1858	0.04	0.00	0	0.41	1.12	0.00
		12	1764	0.04	0.00	0	0.46	1.21	0.00
		13	1694	0.04	0.00	0	0.51	1.27	0.00
		14	1639	0.04	0.00	0	0.56	1.31	0.00
		15	1590	0.04	0.00	0	0.61	1.34	0.00

Stock	Sex	Age a	Initial abundance $N_{a,2015}$ ($.10^3$)	Natural mortality M_a (yr^{-1})	Init. fish. mortality $F_{a,2015}$ (yr^{-1})	$\overline{F}$ weighting δ_a	Weight in stock w_a (kg/ind)	Weight in landings wl_a (kg/ind)	Maturity Mat_a
		16	1546	0.04	0.00	0	0.66	1.36	0.00
		17	1509	0.04	0.00	0	0.71	1.38	0.00
		18	1476	0.04	0.00	0	0.76	1.40	0.00
		19	1449	0.04	0.00	0	0.81	1.42	0.00
		20	1439	0.04	0.00	1	0.86	1.43	0.00
		21	1468	0.04	0.00	1	0.90	1.45	0.00
		22	1559	0.04	0.00	1	0.95	1.46	0.00
		23	1619	0.04	0.00	1	0.99	1.48	0.00
		24	1627	0.04	0.00	1	1.03	1.49	0.00
		25	1611	0.04	0.00	1	1.07	1.50	0.00
		26	1563	0.04	0.00	1	1.11	1.52	0.00
		27	1502	0.04	0.00	1	1.15	1.53	0.00
		28	1443	0.04	0.00	1	1.18	1.55	0.00
		29	1384	0.04	0.00	1	1.22	1.56	0.00
		30	1327	0.04	0.01	1	1.25	1.58	0.00
Orange		31	1340	0.04	0.01	1	1.28	1.59	0.00
roughy		32	1251	0.04	0.01	1	1.31	1.60	0.00
(East)		33	1123	0.04	0.01	1	1.34	1.62	0.00
		34	982	0.04	0.01	1	1.37	1.63	0.00
		35	839	0.04	0.01	1	1.40	1.64	0.00
		36	728	0.04	0.01	1	1.42	1.66	0.00
		37	640	0.04	0.01	1	1.45	1.67	0.00
		38	570	0.04	0.01	1	1.47	1.68	0.00
		39	513	0.04	0.01	1	1.49	1.69	0.00
		40	462	0.04	0.01	1	1.51	1.71	0.00
		41	411	0.04	0.01	1	1.53	1.72	0.00
		42	358	0.04	0.01	1	1.55	1.73	0.00
		43	306	0.04	0.01	1	1.57	1.74	0.00
		44	259	0.04	0.01	1	1.59	1.75	0.00
		45	217	0.04	0.01	1	1.60	1.76	0.00
		46	182	0.04	0.01	1	1.62	1.77	0.00
		47	153	0.04	0.01	1	1.63	1.78	0.00
		48	128	0.04	0.01	1	1.65	1.79	0.00
		49	108	0.04	0.01	1	1.66	1.79	0.00
		50	92	0.04	0.01	1	1.67	1.80	0.00
		51	78	0.04	0.01	1	1.68	1.81	0.00
		52	66	0.04	0.01	1	1.69	1.82	0.00
		53	57	0.04	0.01	1	1.70	1.83	0.00
		54	49	0.04	0.01	1	1.71	1.83	0.00
		55	42	0.04	0.01	1	1.72	1.84	0.00
		56	37	0.04	0.01	1	1.73	1.84	0.00
		57	33	0.04	0.01	1	1.74	1.85	0.00
		58	29	0.04	0.01	1	1.75	1.86	0.00
		59	27	0.04	0.01	1	1.75	1.86	0.00
		60	24	0.04	0.01	1	1.76	1.87	0.00
		61	23	0.04	0.01	1	1.77	1.87	0.00
		62	21	0.04	0.01	1	1.77	1.87	0.00
		63	20	0.04	0.01	1	1.78	1.88	0.00
		64	19	0.04	0.01	1	1.79	1.88	0.00
		65	18	0.04	0.01	1	1.79	1.89	0.00
		66	16	0.04	0.01	1	1.80	1.89	0.00
		67	15	0.04	0.01	1	1.80	1.89	0.00
		68	14	0.04	0.01	1	1.81	1.90	0.00
		69	13	0.04	0.01	1	1.81	1.90	0.00
		70	12	0.04	0.01	1	1.81	1.90	0.00
		71	11	0.04	0.01	1	1.82	1.91	0.00
		72	11	0.04	0.01	1	1.82	1.91	0.00
		73	10	0.04	0.01	1	1.82	1.91	0.00
		74	10	0.04	0.01	1	1.83	1.91	0.00

Stock	Sex	Age	Initial abundance	Natural mortality	Init. fish. mortality	$\overline{F}$ weighting	Weight in stock	Weight in landings	Maturity
		a	$N_{a,2015}$ $(.10^3)$	M_a (yr^{-1})	$F_{a,2015}$ (yr^{-1})	δ_a	w_a (kg/ind)	wl_a (kg/ind)	Mat_a
		75	9	0.04	0.01	1	1.83	1.91	0.00
		76	9	0.04	0.01	1	1.83	1.92	0.00
		77	8	0.04	0.01	1	1.83	1.92	0.00
		78	8	0.04	0.01	1	1.84	1.92	0.00
		79+	121	0.04	0.01	1	1.84	1.92	0.00

Stock	Virgin recruitment $(.10^3)$ R_0	Virgin biomass (t) SSB_0	Steepness h	Recruitment shift μ_R	Recruitment deviation σ_R
School Whiting	273325	7546	0.75	0	0.35
Silver Warehou	11838	18949	0.75	-0.63	0.7
Jackass Morwong (West)	1207	2742	0.7	0	0.7
Jackass Morwong (East)	3103	7046	0.7	0	0.7
Flathead	21977	23100	0.62	0	0.4
Pink ling (East)	1845	7669	0.75	0	0.7
Pink ling (West)	4891	7143	0.75	0	0.7
Redfish	135929	12004	0.75	-0.91	0.7
Orange roughy (East)	8763	41634	0.75	0	0.7

C.2 Fishing activity and catch module

Metiers represented in the model were derived from a multivariate clustering analysis of catch data detailed in Supplementary Material A. Catch and fishing effort at the vessel and metier level were calculated from SESSF logbook data.

C.3 ITQ market module

Quota lease prices for the species not explicitely under TAC management in the simulations were set as fixed parameters and estimated from data collected by the Australian Fisheries Management Authority since July 2017. Transactions between related entities (i.e. related through some type of control or ownership) were removed from the dataset to avoid bias in the estimation. The ratio of the yearly median lease price to the species' ex-vessel price was calculated for the period 2017-2018 and used to estimate a yearly lease price for 2015. Values of those ratios are given in Table C.5.

C.4 Fish price module

Ex-vessel prices for the various species in 2015 were obtained for each sector from Australian Fisheries Statistics [Mobsby, 2018] and are provided in Table C.6.

Table C.5: Ratio between the median lease price and the ex-vessel price for species under quota in the SESSF between 2017 and 2018.
Source: AFMA

Species	Lease price/Fish price
Blue eye Trevalla	0.22
Blue Grenadier	0.05
Blue Warehou	0.11
Flathead	0.29
Gemfish East	0.17
Gemfish West	0.22
Gummy Shark	0.31
Jackass Morwong East	0.17
Jackass Morwong West	0.17
John Dory	0.04
Mirror Dory	0.15
Ocean Perch Inshore	0.16
Ocean Perch Offshore	0.16
Orange Roughy Cascade	confidential
Orange Roughy East	0.21
Orange Roughy South	0.24
Orange Roughy West	0.17
Pink Ling East	0.39
Pink Ling West	0.39
Redfish	0.03
Royal Red Prawn	confidential
Saw Shark	0.25
School Shark	0.54
School Whiting	0.12
Silver Trevally	0.02
Silver Warehou	0.15

C.5 Economic module

Table C.7 summarizes the estimated cost structures for the four gear types in the SESSF. They are based on ABARES economic surveys from 2015 [Bath et al., 2018], which reports financial performance of the average boat for the Commonwealth Trawl Sector (CTS) and the Gillnet, Hook and Trap Sector (GHTS). Personal communication from ABARES allowed to break down sectoral costs per main gear type (trawl and Danish seine for the CTS and gillnet and hooks for the GHTS). Depreciation costs (C_{dep}) per sector were estimated by ABARES using the diminishing value method based on current replacement value and age of the items. Following ABARES methodology, the opportunity cost of capital (C_{opp}) per sector was estimated at 7% per year of capital value. This interest rate represents the long-term average rate of return that could be earned on an investment elsewhere. Crew share ($cshr$) is

Table C.6: Ex-vessel price of the modelled species in the SESSF in 2015.
Source: Mobsby [2018]

Species	Fish price (AU$/kg)	
	CTS	GHTS
Blue eye Trevalla	8.33	9.11
Blue Grenadier	1.30	1.30
Blue Warehou	3.07	3.00
Deepwater Shark	3.64	3.64
Flathead	6.18	6.18
Frostfish	3.50	3.50
Gemfish	2.43	2.43
Gummy Shark	6.29	6.29
Jackass Morwong	3.36	3.36
John Dory	8.66	8.66
King Dory	3.50	3.50
Mirror Dory	3.15	3.15
Ocean Jackets	1.72	1.72
Ocean Perch	5.08	5.08
Orange Roughy	5.59	5.59
Oreos	3.50	3.50
Other species	3.50	3.50
Pink Ling	5.73	5.73
Redfish	3.43	3.43
Ribaldo	3.50	4.35
Royal Red Prawn	4.01	4.01
Saw Shark	1.91	1.91
School Shark	5.99	5.99
School Whiting	3.05	3.05
Silver Trevally	4.49	4.49
Silver Warehou	1.15	1.15
Squids	3.79	3.79

expressed as a percentage of income, variable costs (i.e. fuel costs (C_{fuel}) and other variable costs ($C_{var_{oth}}$)) were calculated per fishing day, and fixed costs and capital costs (depreciation and opportunity costs) estimated to be function of the vessel's income. Assuming fixed and capital costs to be function of the vessel's income allowed to account for the variability in vessels characteristics within sectors (e.g vessel length or engine power which are important determinants of fixed costs and often correlated to the level of catch and derived income). It also enabled to address the fact that some vessels are not only employed to fish in the SESSF (some also operate in state waters or other Commonwealth fisheries) and therefore their fixed costs and capital costs should be redistributed to each fishery accordingly. The ex-vessel price for the modelled species in 2015 was derived from Mobsby [2018] and values are given in Table C.6.

Crew numbers in the fishery were found to be positively correlated with the amount of daily landings as reported in Table C.8.

Table C.7: Cost structures for the four main gear types in the SESSF.
Source: Bath et al. [2018]

sector	*cshr* (% income)	C_{fuel} (AU$/day)	$C_{var_{oth}}$ (AU$/day)	C_{fix} (% income)	C_{dep} (% income)	C_{opp} (% income)
TW	26	2513	2845	11	3	2
DS	46	436	1321	13	5	2
GN	42	564	403	20	7	9
HK	42	590	1208	18	6	5

Table C.8: Estimation of crew numbers in the SESSF.
Source: pers. comm. ABARES

	Daily landings (kg/day)		
	< 350	$[350; 700[$	$\geqslant 700$
Crew numbers	2	3	4

Supplementary Material D

Impact on other modelled stocks

Because our simulations only considered explicit TAC constraints on the two stocks defining each sub-fishery, other stocks in the fishery may be harvested above sustainable levels. Figure D.1 shows the number of stocks (among the 16 for which population dynamics is represented in the model) harvested above their respective F_{20} (top row) and F_{MSY} (bottom row) reference points.

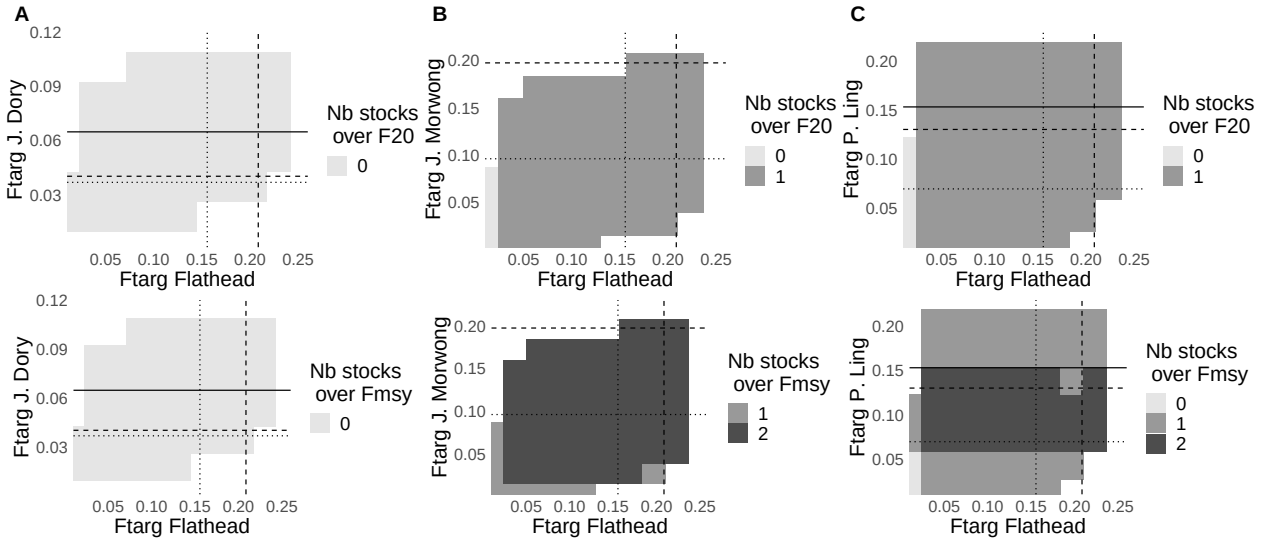

Figure D.1: Number of stocks harvested above F_{20} (top row) and F_{MSY} (bottom row) among those not explicitly under TAC management in the model. Dotted lines show current management targets formulated in terms of fishing mortality rates, dashed lines singles-species F_{MSY} reference points and solid lines (when within the operating domain) F_{20} limit reference points.
Source: output from IAM model.

In scenarios simulated for the flathead - john dory sub-fishery (Figure D.1 A) there is not any unregulated stock being harvested above F_{20} or F_{MSY}. In simulations carried out for both the flathead - jackass-morwong and flathead - pink ling sub-fisheries (Figure D.1 B and

C), john dory gets almost always harvested above F_{20}, and consequently above F_{MSY} (light grey areas), and blue-eye trevalla is harvested above F_{MSY} within dark grey domains.

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