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Supplementary Material

Managing biological, economic and social trade-offs in the Australian Southern and Eastern Scalefish and Shark Fishery

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The effect of fish price model on the operating domain

Fig. S1 compares the space of achievable fishing mortality targets under 2 scenarios: one where the price of fish remains constant (results retrieved from Briton *et al*. 2021) and one where it responds to the quantity of fish landed. The dynamics on fish prices affect the economic incentives for fishers to harvest fish stocks. Indeed, as landings increase, the price of fish decreases, which diminishes economic returns compared to a situation where prices remain constant. As a consequence, it becomes unprofitable for fishers to fully catch the TAC when it is set with a harvest rate above 0.18 year^{-1} for flathead and 0.16 year^{-1} for pink ling, resulting in the operating domain shrinking on the top and right ends between the constant and dynamic price scenarios. Eventually, the operating domain reduces down to below the MSY reference point for flathead and slightly above the F_{20} limit reference point for pink ling.

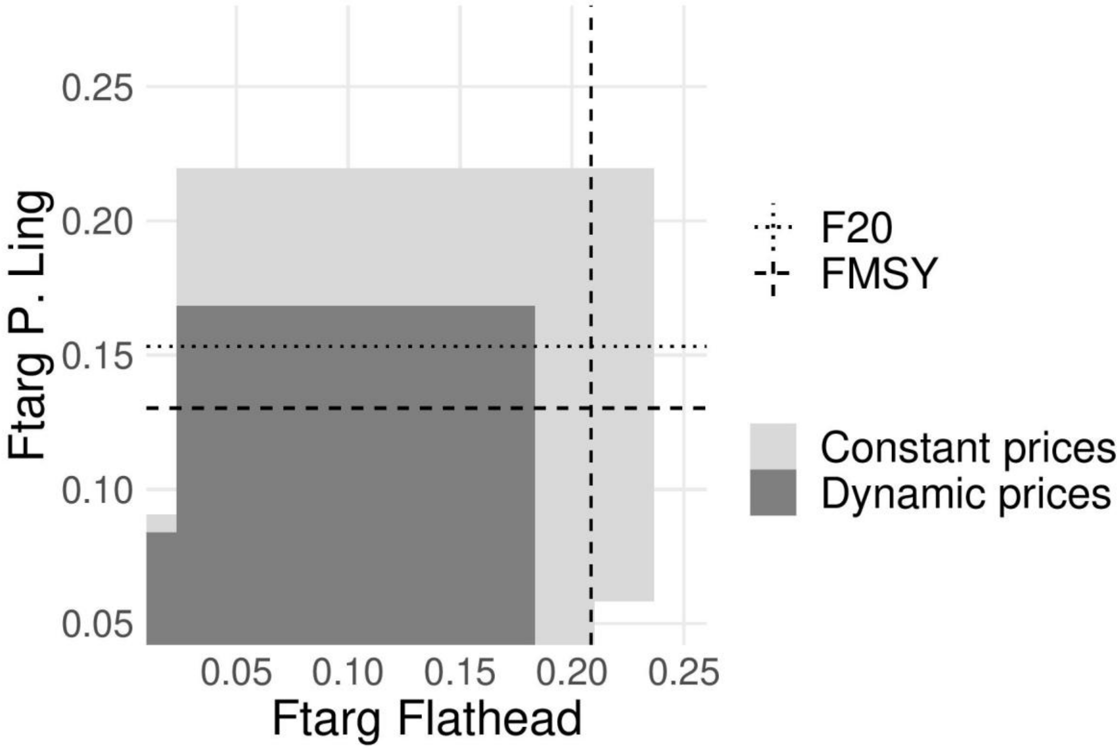

Fig. S1. Comparison of operating domains under the constant (i.e. no price response to changes in the quantities and composition of landings) and dynamic (i.e. the latter responses are considered) fish prices scenarios. The operating domain for the constant fish prices scenario is reproduced from Briton *et al*. (2021). FMSY is the fishing mortality rate maximising yield at equilibrium for the stock and F_{20} the fishing mortality rate associated to an equilibrium biomass equal to 20% of its pre-exploitation value.

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

Biological module

The list of represented stocks and associated population dynamics models is given in Table S1.

Table S2 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 (M. Haddon, see https://rdrr.io/github/haddonm/datalowSA/) and using time series of catches from Castillo-Jordán *et al*. (2018) and catch rates from Sporcic and Haddon (2020). 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*. (2020)

— Jackass morwong (East): Day and Castillo-Jordán (2020*a*)

— Jackass morwong (West): Day and Castillo-Jordán (2020*b*)

— Tiger flathead: Day (2018)

— Blue grenadier: Castillo-Jordán and Tuck (2018)

— Pink ling (East): Sandra Curin-Osorio, pers. comm.

— Pink ling (West): Sandra Curin-Osorio, pers. comm.

— Redfish: Tuck *et al*. (2018)

— Orange roughy (East): Tuck *et al*. (2020)

Table S1. Modelled stocks in the Southern and Eastern Scalefish and Shark Fishery.

Stock (species)	IAM dynamics
Blue-eye trevalla (*Hyperoglyphe antarctica*)	Surplus production
Blue grenadier (*Macruronus novaezelandiae*)	Age- and sex-based
Blue warehou (*Seriolella brama*)	Static
Deepwater sharks complete list in Patterson *et al*. (2018)	Static
Eastern school whiting (*Sillago flindersi*)	Age- and sex-based
Elephantfish (*Callorhinchus milii*)	Static
Flathead (*Neoplatycephalus richardsoni*) and 4 other species	Age- and sex-based
Gemfish (*Rexea solandri*)	Static
Gummy shark (*Mustelus antarcticus*)	Surplus production
Jackass morwong (East) (*Nemadactylus macropterus*)	Age- and sex-based
Jackass morwong (West) (*Nemadactylus macropterus*)	Age- and sex-based
John dory (*Zeus faber*)	Surplus production
Mirror dory (*Zenopsis nebulosa*)	Surplus production
Ocean jacket (*Nelusetta ayraud*)	Static
Ocean perch (*Helicolenus barathri, H. percoides*)	Surplus production
Orange roughy (East) (*Hoplostethus atlanticus*)	Age- and sex-based
Orange roughy (South) (*Hoplostethus atlanticus*)	Static
Orange roughy (West) (*Hoplostethus atlanticus*)	Static
Oreo dories complete list in Patterson *et al*. (2018)	Static
Pink ling (East) (*Genypterus blacodes*)	Age- and sex-based
Pink ling (West) (*Genypterus blacodes*)	Age- and sex-based
Redfish (*Centroberyx affinis*)	Age- and sex-based
Ribaldo (*Mora moro*)	Static
Royal red prawn (*Haliporoides sibogae*)	Static
Sawshark (*Pristiophorus cirratus, P. nudipinnis*)	Static
School shark (*Galeorhinus galeus*)	Surplus production
Silver trevally (*Pseudocaranx georgianus*)	Static
Silver warehou (*Seriolella punctata*)	Age- and sex-based

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

$$F_{MSY_s} = \frac{1}{nb_s \sum_a \delta_{s,a}} \sum_a \frac{\delta_{s,a}}{N_{s,a}} \sum_g F_{MSY_{s,g,a}} N_{s,g,a}$$

$\delta_{s,a}$ = 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 S2.

The same approach was followed to calculate the limit reference point F_{20_s} 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 S2. Calibration of the model IAM for the Australian Southern and Eastern Scalefish and Shark Fishery.

Stock	Initial biomass (Mg)	Growth rate (year^{-1})	Carrying capacity (Mg)	Initial fishing mortality (year^{-1})
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 (year^{-1})	Initial fishing mortality $F_{a,2015}$ (year^{-1})	$\bar{F}$ weighting δ_a	Weight in stock w_a (kg individual^{-})	Weight in landings wl_a (kg individual^{-})	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
Jackass morwong (West)	Both	0	1110	0.15	0.00	0	0.07	0.10	0.00
		1	930	0.15	0.00	0	0.1	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

Stock	Sex	Age	Initial abundance	Natural mortality	Initial fishing mortality	$\bar{F}$ weighting	Weight in stock	Weight in landings	Maturity
		a	$N_{a,2015}$ (10^3)	M_a (year^{-1})	$F_{a,2015}$ (year^{-1})	δ_a	w_a (kg individual^{-})	wl_a (kg individual^{-})	Mat_a
		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
		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
Flathead	F	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

Stock	Sex	Age a	Initial abundance $N_{a,2015}$ (10^3)	Natural mortality M_a (year^{-1})	Initial fishing mortality $F_{a,2015}$ (year^{-1})	$\bar{F}$ weighting δ_a	Weight in stock w_a (kg individual^{-})	Weight in landings wl_a (kg individual^{-})	Maturity Mat_a
		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
	M	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
Blue grenadier	F	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

Stock	Sex	Age a	Initial abundance $N_{a,2015}$ (10^3)	Natural mortality M_a (year^{-1})	Initial fishing mortality $F_{a,2015}$ (year^{-1})	$\bar{F}$ weighting δ_a	Weight in stock w_a (kg individual^{-})	Weight in landings wl_a (kg individual^{-})	Maturity Mat_a
		20+	1278	0.17	0.02	0	4.15	4.16	0.84
	M	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
Pink ling (East)	F	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

Stock	Sex	Age a	Initial abundance $N_{a,2015}$ (10^3)	Natural mortality M_a (year^{-1})	Initial fishing mortality $F_{a,2015}$ (year^{-1})	$\bar{F}$ weighting δ_a	Weight in stock w_a (kg individual^{-})	Weight in landings wl_a (kg individual^{-})	Maturity Mat_a
		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
		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
Pink ling (west)	F	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
	M	0	2309	0.29	0.00	0	0.01	0.03	0.00

Stock	Sex	Age a	Initial abundance $N_{a,2015}$ (10^3)	Natural mortality M_a (year^{-1})	Initial fishing mortality $F_{a,2015}$ (year^{-1})	$\bar{F}$ weighting δ_a	Weight in stock w_a (kg individual^{-})	Weight in landings wl_a (kg individual^{-})	Maturity Mat_a
		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
		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
Redfish	F	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

Stock	Sex	Age a	Initial abundance $N_{a,2015}$ (10^3)	Natural mortality M_a (year^{-1})	Initial fishing mortality $F_{a,2015}$ (year^{-1})	$\bar{F}$ weighting δ_a	Weight in stock w_a (kg individual^{-})	Weight in landings wl_a (kg individual^{-})	Maturity Mat_a
		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
	M	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
		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	03	0.03	0.00
		39+	2	0.10	0.06	0	0.03	0.03	0.00
Orange Roughy (East)	F	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

Stock	Sex	Age a	Initial abundance $N_{a,2015}$ (10^3)	Natural mortality M_a (year^{-1})	Initial fishing mortality $F_{a,2015}$ (year^{-1})	$\bar{F}$ weighting δ_a	Weight in stock w_a (kg individual^{-})	Weight in landings wl_a (kg individual^{-})	Maturity Mat_a
		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
		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 roughy (East)		47	153	0.04	0.01	1	1.66	1.80	0.76
		48	128	0.04	0.01	1	1.67	1.81	0.77
		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

Stock	Sex	Age	Initial abundance	Natural mortality	Initial fishing mortality	$\bar{F}$ weighting	Weight in stock	Weight in landings	Maturity
		a	$N_{a,2015}$ (10^3)	M_a (year^{-1})	$F_{a,2015}$ (year^{-1})	δ_a	w_a (kg individual^{-})	wl_a (kg individual^{-})	Mat_a
		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
	M	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
		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 roughy (East)		31	1340	0.04	0.01	1	1.28	1.59	0.00
		32	1251	0.04	0.01	1	1.31	1.60	0.00
		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

Stock	Sex	Age a	Initial abundance $N_{a,2015}$ (10^3)	Natural mortality M_a (year^{-1})	Initial fishing mortality $F_{a,2015}$ (year^{-1})	$\bar{F}$ weighting δ_a	Weight in stock w_a (kg individual^{-})	Weight in landings wl_a (kg individual^{-})	Maturity Mat_a
		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
		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 (Mg) 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

Fishing activity and catch module

Metiers represented in the model were derived from a multivariate clustering analysis of catch data detailed in the 'Metier and fleet definition in the Australian Southern and Eastern Scalefish and Shark Fishery' section. Catch and fishing effort at the vessel and metier level were calculated from SESSF logbook data.

ITQ market module

Quota lease prices for the species not explicitly 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 S3.

Table S3. Ratio between the median lease price and the ex-vessel price for species under quota in the SESSF between 2017 and 2018.

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

Source: AFMA

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 S4. Own- and cross-price flexibilities estimated for the SESSF by Bose (2004) were used to calibrate fish price dynamics. Only significant coefficients were kept.

Economic module

Table S5 summarises 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 Gill-net, 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 gill-net 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 expressed as a percentage of income, variable costs (i.e. fuel costs, C_{fuel}, and other variable costs, C_{varoth}) 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 S4.

Table S4. Ex-vessel price of the modelled species in the SESSF in 2015.

	Fish price (A$ kg^{-1})	
Species	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

Source: Mobsby (2018).

Crew numbers in the fishery were found to be positively correlated with the amount of daily landings as reported in Table S6

Table S5. Cost structures for the four main gear types in the SESSF.

Sector	$cshr$ (% income)	C_{fuel} (A$ day^{-1})	$C_{var_{oth}}$ (A$ day^{-1})	C_{fix} (A$ day^{-1})	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

Source: Bath *et al*. (2018).

Table S6. Estimation of crew numbers in the SESSF.

	Daily landings (kg day^{-1})		
	<350	350-700	>700
Crew numbers	2	3	4

Source: ABARES, pers. comm.

Metier and fleet definition in the Australian Southern and Eastern Scalefish and Shark Fishery

The aim of this analysis was twofold:

1. define metiers for the South East Shark and Scalefish Fishery (excl. the Great Australian Bight and East Coast Deepwater Trawl sectors),
2. 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), which is "a group of fishing operations targeting a similar (assemblage of) species, using similar gear, during the same period of the year 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.

Material and methods

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).

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 2-D matrix M, with rows referring to logbook events (index *le*), and columns to species (index *sp*), and entry $M_{le,sp}$ defined as:

$$M(le, sp) = \frac{p_{sp} L_{le,sp}}{\sum_{sp} p_{sp} L_{le,sp}}$$

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 are 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 A7 which reduced the size of the dataset to cluster and resulted in more relevant clusters. The east–west boundary is the 147° meridian (also used in the management of certain stocks).

Table S7. Gear classification and groups used for clustering.

Sector	Gear	Logbook abbrev.	Group for clustering	Number of events in 2012–2017
CTS	Otter trawl	TDO,TW	Trawl - East	59383
			Trawl - West	21044
	Danish seine	DS	Danish seine	54984
	Gill-net	GN	Gill-net	42528
GHTS	Automatic longline	AL		
	Bottomline	BL	Hooks	17042
	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.

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 2-D 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, Gill-net 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.

Results

Metiers

Tables S8–S12 describe 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, Gill-net 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 250 m and to the mixed slope metier when operating at depths greater than 250 m.

Fleets

Table S13 summarises 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, Gill-net and Hooks. After Step 2, those cluster have been merged into respectively 5, 2, 1 and 5 fleets.

Table S8. Metier description for eastern zones (10,20,30) in the CTS of the SESSF.

Cluster step 1	Main spp.	Secondary spp.	Depth zone	Zone	Season	Percentage hauls	Cluster step 2.1	Cluster step 2.2 (metier)
13	Flathead (87%)		Shelf	10; 20; 30	All year	23	Flathead	Flathead
1	Flathead (61%)	John dory, squid, latchet, jackets, others	Shelf	10; 20; 30	All year	24	Flathead	Flathead
2	RRP (87%)	Mirror dory, others	Shelf	Ulladulla	All year	3	RRP	RRP
3		Flathead John dory, squid, others	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	Morwong (53%)	Flathead, jackets, squid, others	Shelf	20	Summer	2	Morwong	Morwong
7	Silver trevally (62%)	Flathead, jackets, others	Shelf	10	Dec–Jan; April–June	3	Silver trevally – flathead	Mixed shelf
11	School whiting (57%)	Flathead, others	Shelf	10	April–May	2	School whiting	Mixed shelf
12		Others (65%), flathead, squid	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	Squid	Squid
10	Ling (69%)	Ocean perch – offshore, blue grenadier, mirror dory	Slope	20	Not in summer	7	Ling	Ling
6	Ocean perch – offshore (59%)	Ling, mirror dory, gemfish, others	Slope	10	July–Oct	3	Ocean perch – ling	Mixed slope
8		Blue grenadier, mirror dory, gemfish, others	Slope	10; 20; 30	All year	6	Mixed slope	Mixed slope
14	Frostfish (60%)	Mirror dory, 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

Table S9. Western CTS (from Briton).

Cluster step 1	Main spp.	Secondary spp.	Depth zone	Zone	Season	Percentage hauls	Cluster step 2.1	Cluster step 2.2 (metier)
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	Summer–Autumn	10	Deepwater basket	Deepwater basket

Table S10. Danish seine CTS.

Cluster step 1	Main spp.	Secondary spp.	Depth zone	Zone	Season	Percentage hauls	Cluster step 2.1	Cluster step 2.2 (metier)
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

Table S11. Gill-net sector.

Cluster step 1	Main spp.	Secondary spp.	Depth zone	Zone	Season	Percentage hauls	Cluster step 2.1	Cluster step 2.2 (metier)
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	Gummy shark	Gummy shark
7		Other species, gummy shark	Shelf	50–60	More in winter	4	Mixed	Gummy shark
3		Saw shark, gummy shark, boar fishes	Shelf	60	More in winter	3	Mixed	Gummy shark

Table S12. Hook sector.

Cluster step 1	Main spp.	Secondary spp.	Depth zone	Zone	Season	Percentage hauls	Cluster step 2.1	Cluster step 2.2 (metier)
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
4	Blue-eye trevalla (90%)		Slope	30	November–March	9	Blue-eye trevalla	Blue-eye trevalla
3	Pink ling (78%)	Blue-eye trevalla, ribald, 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 S13. Description of fleets.

Sector	Step 1 cluster	Metiers	Number of vessel-years	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
Gill-net	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	Mixed drop-liner
	6	AL.Pink.Ling (39%), AL. Mixed. Scalefish (22%), AL.Blue.eye.Trevalla (18%)	10	Mixed auto-liner

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