Sablefish Apportionment

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At the December 2017 SSC meeting, the SSC requested that a review be conducted of the method to be used for spatial allocation (apportionment) of sablefish ABC and OFL. This document summarizes progress and outlines planned analyses to evaluate alternative options for apportionment of sablefish ABC/OFL to IFQ holders by management area.

> ***"The SSC approved the authors and Joint Plan Team's recommendations for Tier, ABC and OFL. These recommendations include adjustments for the magnitude of the 2014 year-class and whale depredation.*** *The authors and the JPT agreed that the fixed area apportionments used in 2016 should be applied again this year. The author noted that the CIE reviewers concluded that continued use of the fixed area approach did not appear to pose a conservation concern. The SSC notes that the authors have indicated that a complete review of the method to be used for spatial allocation will be forthcoming. The SSC requests conduct of this analysis in 2018."*

As specified in the 2013 (November) Groundfish Plan Team minutes,

> *"Apportionment of the sablefish ABC has two goals: 1) to take into account the actual changes in the distribution of the population, and 2) to reduce interannual variability in area ABCs. These goals are not being met because recent changes in apportionment are too large to reflect actual distributional shifts. The problem is thought to be due to the approach not taking into account measurement error, leading to rapid changes in some area estimates and large swings in apportionments. As an example, the status quo apportionment would increase the 2014 Bering Sea ABC by 20% although ABCs for all the other areas would decline by 15–20%. There is higher uncertainty in the data for the Bering Sea because this area is only surveyed every other year and fishery CPUE is estimated with limited observer and logbook data. A possible solution is to use a random effects model, which the authors will explore next year. Two options were proposed for this year's assessment: 1) go with the model ABC and standard apportionment, or 2) use the model ABC and fix apportionment at the same values as used last year and apply a 15% decrease across the board, which the authors recommended. This would be an interim measure to smooth ABC variability until more analyses are completed."*

The 2014 apportionment of recommended ABC to management areas was fixed at 2013 ABC apportionment values. Each year since, both 'status quo' (exponentially weighted moving average) and 'fixed' values (fixed at 2013 proportions) have been presented in the SAFE chapter, and the 'fixed' values have been used in apportionment. In 2018, two projects regarding sablefish apportionment have been completed and a third, more comprehensive project has been initiated. The completed projects are 1) a Spatial Processes and Stock Assessment Methods (SPASAM) workgroup project, which applied spatial simulations to a sablefish-like species, and 2) a second project which provided a 'retrospective' analysis of sablefish apportionment. A more comprehensive project, which is in progress, is 3) a sablefish Management Strategy Evaluation focusing on apportionment.

1) SPASAM workgroup spatial processes simulation (manuscript in prep)

The SPASAM group is a multi-Center collaboration comprised of Katelyn Bosley (NRC Post-Doc), Aaron Berger (NWFSC), Jon Deroba (NEFSC), Dan Goethel (SEFSC), Dana Hanselman (AFSC), Brian Langseth (PIFSC), and Amy Schueller (SEFSC). The SPASAM project modeled spatial processes for three test species (menhaden, hake, and sablefish). The simulation study using a sablefish-like operating model parameterization, found that a wide-range of fishing mortality combinations across management regions achieved >90% of the long-term maximum system yield when simulation accounted for movement between regions. When the stock was considered to be a meta-population with little or no-movement, the range of optimal fishing mortalities for each region became much more restricted, with a general tendency to fish harder in the areas with the oldest selectivity-at-age. Since sablefish are known to have a high level of interchange between management areas, this work suggests that socioeconomic factors may be more important in determining harvest apportionment between regions, because high yields can be achieved by a number of apportionment strategies.

2) Retrospective apportionment

Each year the sablefish stock assessment model estimates ABC and OFL values that are subsequently apportioned to IFQ shareholders in six management regions. A simple method for comparing the suite of alternative apportionment alternatives is to apply each alternative option to the annual ABCs estimated by past assessments. This approach can help highlight the underlying characteristics of each apportionment alternative (e.g., interannual variability, spatial variability). A caveat to this retrospective approach is that there is no feedback between apportioned harvest and the underlying fish population. The status of the stock and historic ABCs were a result of the actual strategy applied and not the apportionment alternative being examined. As such these retrospective analyses only intended illustrate differences in annual apportionment, not evaluate the relative performance of alternatives.

We have applied a suite of apportionment options identified by the sablefish stock assessment authors. Further refinement of apportionment alternatives will continue with input from stakeholders. Apportionment options were applied, retrospectively, to sablefish ABC values from 2005-2018 stock assessments. The apportionment options presented here are a subset of the options that may be selected for use in the full apportionment MSE that is under development. Retrospective apportionment alternatives include:

Name of option	**Description**	**Rationale**
Status quo	5-yr exponentially weighted moving average of fishery and survey indices; survey weight is 2x fishery weight	This is the original, NPFMC-approved method
Static	The apportionment proportions from the 2013 assessment that have been applied as fixed proportions for 2014-2018	This has been used for several years to reduce interannual variability
Equal	Each region receives 1/6 of the ABC	A simple option to use as a basis for comparisons

Equilibrium	Based on the stationary distribution of the movement rates (using approximate but realistic values for EY and WY until a 6 area movement model is configured. The EG proportion is 0.372 (EY+WY), split 37% to 63% for WY and EY/SEO for now)	Will provide interannual stability, has biological basis
Partially fixed	BS and AI receive 10% of the ABC each, WG, CG, WY, and EY are apportioned based on status quo	By fixing the BS and AI at 10% (or another value), the areas that generally have high interannual variation are fixed, ideally stabilizing the other management areas. Ten percent is a reasonable placeholder value; other values based on historical proportions of apportionment may be explored.
Non-exponential status quo	A 5-yr moving average of fishery and survey indices	Will reduce interannual variability by reducing high weights on recent years by using 5 year, unweighted mean
Biomass based	Based on the proportion of the estimated biomass in each region from the most recent year of the NMFS sablefish longline survey	Uses most current biomass estimates only and may be most adaptable to rapid changes in biomass (spatially and overall)
Exponential, fishery only	Similar to 'status quo' option but using fishery index only	Examines the impact of a single data source (fishery)
Exponential, survey only	Similar to 'status quo' option but using survey index only	Examines the impact of a single data source (survey)
Maturity based, non-exponential	Based on the proportion of females in each region larger than the length at 50% maturity (~65.1 cm) using longline survey data; BS and AI data carried forward from previous sampled year in the 'off' sampling year, 5-year running average	This approach attempts to approximate the relative distribution of both the spawning biomass and higher-valued fish
Maturity based, exponential	Based on the proportion of females in each region larger than the length at 50% maturity (~65.1 cm) using survey data, BS and AI data carried forward from previous sampled year in the 'off' sampling year, 5-year exponentially weighted running average	This approach attempts to approximate the relative distribution of both the spawning biomass and higher-valued fish, but would be more focused on current distribution of female SSB
Random effects	Apportionment to region based on the proportions of biomass estimated by the RE model applied to the longline survey, using 0.05 CV	This option is used for apportionment in some other species

Apportionment options that may be considered for the MSE but are not used in retrospective apportionment analyses:

Penalized	ABC cannot increase or decrease for a given area by more than 5% (or other specified value)	Any value can be chosen for the cap on interannual change, however, this option could be in conflict with the established NPFMC harvest control rule
Measurement error	Interannual changes in apportionment for an area are tied to the CV of the survey	Changes with high CVs should be given less weight in the annual apportionment process (e.g., the Bering Sea area consistently has higher larger changes with a higher CV than areas in the GOA)

It is not possible to examine regional biological sustainability via 'retrospective' type analyses of apportionment because of the lack of feedback in the ABC-setting process. However, interannual stability in ABC and a minimum threshold for regional ABC have been discussed as potential performance metrics and can be examined for previous years. Full tables of annual ABC values for each retrospective apportionment option are presented in Appendix 1. The proportion by area of ABC values for each retrospective apportionment option are in Appendix 2.

For these alternative apportionment options, we examined 'stability' in ABC for each apportionment option as the proportion of years and management areas where the absolute change in ABC between adjacent years was less than *X*% (Table 1); a higher *X%* is representative of a higher tolerance for larger interannual change in ABC. We examined stability threshold values *X* ranging from 1-50% for illustrative purposes. For example, for the Status Quo apportionment option the absolute interannual change in ABC is less than 1% for only 6% of years and management areas (relatively unstable when tolerance for interannual change is low), but all years and areas have less than a 50% change in ABC from year to year. Generally speaking, higher values at each threshold for interannual ABC variation (columns, Table 1) are 'better', indicating a greater proportion of year-area combinations would have resulted in less variation.

At the 5% threshold for interannual change in ABC, the Non-exponential-, Maturity-, and Exponential Maturity-based apportionment options were the most stable when looking retrospectively at ABC values; about 1/3 of area-year combinations had less than 5% change in ABC between years (Table 1). Most apportionment options were not very stable when the threshold of acceptable interannual change was below 15%. The Biomass-based and Random Effects apportionment options, where ABC/OFL is apportioned to management areas using information from the longline survey biomass estimates, were the least stable under most of the interannual change thresholds examined and is likely undesirable from a stakeholder perspective. However, this suggests that the Biomass-based and Random effects options might also be the most responsive to changes in biomass, if that was the primary goal. Comparison of the Status quo and Static apportionment methods shows that the Static method is generally more stable (more area-years fall under the specific threshold) than the Status quo method, which is expected and was the desired outcome when moving to the Static method.

Table 1. The proportion of year (2005-2018) and management area combinations where the absolute value of the change in ABC between two adjacent years for each management region is less than the % indicated (1% to 50%). A higher cell value means that apportionment option is more stable, and less subject to interannual changes in ABC. Color scale is by column; green shades have more interannual stability, yellow and orange are moderate, and red is the least stable.

	Maximum absolute interannual change in ABC:							
Apportionment Method:	**1%**	**5%**	**10%**	**15%**	**20%**	**25%**	**30%**	**50%**
Status quo	6%	24%	54%	73%	86%	90%	97%	100%
Static	15%	23%	54%	85%	100%	100%	100%	100%
Equal	15%	23%	54%	85%	100%	100%	100%	100%
Equilib	15%	23%	54%	85%	100%	100%	100%	100%
Partially fixed	6%	23%	58%	79%	94%	97%	100%	100%
Non-exponential	8%	35%	59%	77%	94%	100%	100%	100%
Biomass based	4%	19%	38%	50%	58%	67%	72%	92%
Exp Fishery wt	1%	22%	49%	74%	92%	97%	100%	100%
Exp Survey wt	1%	24%	50%	72%	79%	87%	91%	100%
Mature	9%	38%	56%	73%	87%	95%	100%	100%
Exp Mature	9%	36%	51%	65%	79%	86%	94%	97%
RE model	4%	24%	38%	51%	60%	67%	72%	92%

The average values of absolute interannual change for each management area and apportionment method are also informative (Table 2). The Static, Equal, Equilibrium, and Non-exponential options have the lowest interannual variation. The Biomass based, Random effects, Exponential survey, and Exponential maturity options are generally the most unstable for many management areas.

Table 2. Average absolute interannual percent change in ABC across years 2005-2018, for each management area and apportionment method.

	Management area					
Apportionment Method:	**Bering Sea**	**Aleutian Islands**	**Western GOA**	**Central GOA**	**West Yakutat**	**East Yakutat/SEO**
Status quo	12%	10%	14%	12%	11%	9%
Static	9%	9%	9%	9%	9%	9%
Equal	9%	9%	9%	9%	9%	9%
Equilib	9%	9%	9%	9%	9%	9%
Partially fixed	9%	9%	14%	10%	10%	8%
Non-exponential	10%	10%	9%	9%	10%	8%
Biomass based	38%	17%	36%	17%	18%	14%
Exp fishery wt	10%	10%	9%	12%	13%	11%
Exp survey wt	17%	12%	17%	12%	12%	8%
Mature	10%	12%	12%	10%	10%	7%
Exp Mature	19%	9%	18%	12%	10%	9%
RE model	38%	16%	35%	16%	17%	13%

A minimum threshold for ABC in each region may be another management target of interest to stakeholders and managers. Table 3 shows a range of potential minimum per-region ABC values and the proportion of years and areas where the minimum value is obtained, for each of the retrospective apportionment options. All of the apportionment options presented maintain ABC levels above 500 tons for all years and areas examined. No apportionment method results in an ABC above 2000 tons in 100% of years and areas.

Table 3. Proportion of year (2005-2018) and management areas combinations where the minimum ABC is greater than the specified minimum threshold *X* (*X* ranges from 100-2500 tons).

	Mean proportion of years and areas that ABC is greater than *X* tons:								
Apportionment Method:	**100**	**250**	**500**	**1000**	**1250**	**1500**	**1750**	**2000**	**2500**
Status quo	100%	100%	100%	100%	99%	90%	81%	65%	47%
Static	100%	100%	100%	100%	99%	87%	72%	56%	36%
Equal	100%	100%	100%	100%	100%	100%	100%	92%	69%
Equilib	100%	100%	100%	100%	97%	90%	83%	67%	45%
Partially fixed	100%	100%	100%	100%	97%	87%	67%	55%	37%
Non-exponential	100%	100%	100%	100%	99%	90%	76%	65%	50%
Biomass based	100%	100%	100%	97%	92%	86%	73%	64%	45%
Exp Fishery wt	100%	100%	100%	100%	96%	90%	77%	68%	47%
Exp Survey wt	100%	100%	100%	100%	99%	91%	81%	60%	47%
Mature	100%	100%	100%	97%	85%	71%	58%	55%	29%
Exp Mature	100%	100%	100%	96%	87%	67%	59%	53%	32%
RE model	100%	100%	100%	97%	92%	87%	73%	64%	45%

Based on these simple retrospective analyses, it's evident that there will be tradeoffs between stability and maintaining a minimum level of catch in each region, and these analyses don't yet include other more complex socioeconomic or biological factors for consideration of performance metrics. These will be examined to the extent possible in the full apportionment MSE that is under development.

3) Apportionment MSE

Work has begun to develop a generalized, six-area, age-structured, sex-specific Operating Model (OM) which will be used to generate 'true' sablefish data for a Management Strategy Evaluation under several alternative movement scenarios. This will allow us to assess the sensitivity of apportionment outcomes to alternative movement rates among areas (states of nature). The OM will be parameterized based on demographic parameters estimated by the current assessment model (i.e. our best picture of stock dynamics). Two Estimation Models (EMs) have been developed; one is a single area, panmictic model similar to the model currently used for management, the other is a three area sablefish assessment model splitting management areas into the western area (BS/AI/WG), Central Gulf area, and Eastern Gulf area. Having two EMs to compare allows us to identify the key tradeoffs to alternative methods of apportionment under two different stock assessment models.

This work is focused around two questions:

1. What are the tradeoffs among the different apportionment options and is there one (or more) option that maintain regional and overall biomass at or above B40 reference point, with acceptable stability in ABC for stakeholders?
2. What are the tradeoffs in using a single area EM vs a spatial EM with respect to how well the EM describes the 'true' underlying population?

A preliminary list of management objectives and performance metrics have been identified that will serve as the basis for examination of tradeoffs between each candidate apportionment method. There will be ongoing discussion with stakeholders and managers to identify specific values for threshold and targets used in performance metrics, and to identify additional objectives and performance metrics.

Management Objective	**Performance Metric**
Reduce variation in regional ABC changes from year to year.	Percent of time ABC apportioned to a region changes by no more than *X*%.
Maintain a sustainable population of sablefish for all Alaska	Percent of time spawning biomass is above B40% and B35% for management areas summed.
Maintain a sustainable population of sablefish in each management area	Percent of time spawning biomass is above a specific level (such as B40% or other threshold) for each region.
Maintain a minimum level of harvest ABC in every region.	Percent of time ABC in region *r* is greater than specified threshold *x*.
Minimize fishing on immature fish.	Proportion of the total population that is larger than the length at 50% maturity for each region.

Ongoing and iterative discussions with stakeholders will be a critical component of this project. In March 2018, stock assessment staff attended the annual Alaska Department of Fish and Game (ADFG) sablefish meeting in Sitka, AK and gave a short presentation on progress of the sablefish apportionment MSE. This presentation included a brief overview of Management Strategy Evaluation, covered the potential apportionment options to be tested, the objectives and performance measures that will be analyzed in an MSE, and presented some preliminary results on the 'apportionment retrospective' analyses. Based on these initial discussions with a small subset of stakeholders, we will work on restructuring how these complex topics are presented to maximize stakeholder understanding of the objectives of the MSE process and foster stakeholder buy-in and participation. We will also continue to seek input from stakeholders and managers regarding management objectives and ways to measure performance of the apportionment options to ensure they fully reflect stakeholder objectives.

We have mapped out a tentative timeline for completion of this project:

November 2018: Continue static apportionment, while presenting standard (status-quo) apportionment for reference.

Spring 2019: Meet with stakeholders in-person or over video conference to further refine objectives and metrics to test.

September 2019: Update Plan Team with preliminary results of simulations for feedback.

November 2019: Continue with static apportionment unless directed to adopt something early from preliminary results.

2020: Finalize MSE, recommend alternatives based on desired properties of apportionment for potential adoption for 2021 fishing season.

Appendix 1. Apportionment by management region (in tons) for each 'retrospective' apportionment method applied to ABC values for 2005-2018.

Apportionment method:	**Area**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
ABC - all areas		21000	21000	20100	18030	16080	15230	16040	17250	16230	13722	13657	11795	13509	15380
Status quo	BS	2697	2969	2976	2936	2792	2852	2885	2284	1632	1940	2254	1860	1902	2224
Status quo	AI	2899	2677	2570	2343	2138	2011	1870	2024	2111	1775	1821	1611	2243	2686
Status quo	WG	2364	2651	2442	1910	1638	1714	1605	1831	1776	1353	1419	1125	1423	1533
Status quo	CG	6971	6609	6233	5414	4898	4385	4610	5641	5457	4325	3851	3349	3594	4201
Status quo	WY	2243	2089	2082	1886	1579	1448	1849	2000	1784	1412	1401	1349	1585	1765
Status quo	EY/SEO	3827	4005	3797	3541	3035	2820	3221	3469	3469	2916	2911	2501	2763	2970
Static	BS	2050	2050	1962	1760	1570	1487	1566	1684	1584	1339	1333	1151	1319	1501
Static	AI	2771	2771	2652	2379	2122	2010	2117	2276	2142	1811	1802	1557	1783	2030
Static	WG	2265	2265	2168	1945	1735	1643	1730	1861	1751	1480	1473	1272	1457	1659
Static	CG	7163	7163	6856	6150	5485	5195	5471	5884	5536	4681	4658	4023	4608	5246
Static	WY	2409	2409	2306	2069	1845	1747	1840	1979	1862	1574	1567	1353	1550	1765
Static	EY/SEO	4341	4341	4155	3727	3324	3148	3316	3566	3355	2837	2823	2438	2793	3179
Equal	BS	3500	3500	3350	3005	2680	2538	2673	2875	2705	2287	2276	1966	2252	2563
Equal	AI	3500	3500	3350	3005	2680	2538	2673	2875	2705	2287	2276	1966	2252	2563
Equal	WG	3500	3500	3350	3005	2680	2538	2673	2875	2705	2287	2276	1966	2252	2563
Equal	CG	3500	3500	3350	3005	2680	2538	2673	2875	2705	2287	2276	1966	2252	2563
Equal	WY	3500	3500	3350	3005	2680	2538	2673	2875	2705	2287	2276	1966	2252	2563
Equal	EY/SEO	3500	3500	3350	3005	2680	2538	2673	2875	2705	2287	2276	1966	2252	2563
Equilibrium	BS	1939	1939	1856	1664	1484	1406	1481	1592	1498	1267	1261	1089	1247	1420
Equilibrium	AI	2871	2871	2748	2465	2198	2082	2193	2358	2219	1876	1867	1612	1847	2102
Equilibrium	WG	2741	2741	2624	2353	2099	1988	2094	2252	2118	1791	1783	1540	1763	2007
Equilibrium	CG	5634	5634	5392	4837	4314	4086	4303	4628	4354	3681	3664	3164	3624	4126
Equilibrium	WY	2892	2892	2768	2483	2214	2097	2209	2375	2235	1890	1881	1624	1860	2118
Equilibrium	EY/SEO	4924	4924	4713	4228	3770	3571	3761	4045	3806	3217	3202	2766	3168	3606
Part.fixed	BS	2100	2100	2010	1803	1608	1523	1604	1725	1623	1372	1366	1180	1351	1538

Part.fixed	AI	2100	2100	2010	1803	1608	1523	1604	1725	1623	1372	1366	1180	1351	1538
Part.fixed	WG	2592	2912	2703	2156	1888	2011	1834	1950	1846	1480	1626	1280	1651	1808
Part.fixed	CG	7602	7231	6889	6126	5655	5150	5251	5966	5650	4741	4379	3775	4137	4945
Part.fixed	WY	2440	2280	2298	2135	1820	1704	2094	2143	1863	1549	1596	1525	1828	2072
Part.fixed	EY/SEO	4166	4376	4189	4007	3501	3319	3653	3741	3624	3207	3324	2856	3191	3479
Non-exp	BS	2814	2909	2837	2628	2564	2652	2853	2825	2296	1934	1901	1603	1948	2442
Non-exp	AI	3063	2909	2719	2375	2047	1970	2020	2137	2047	1705	1718	1574	2008	2415
Non-exp	WG	2608	2633	2425	2070	1744	1729	1659	1770	1738	1432	1400	1201	1379	1519
Non-exp	CG	6607	6635	6364	5652	4984	4487	4693	5262	5130	4306	4213	3626	3834	4177
Non-exp	WY	2116	2078	2057	1877	1648	1492	1705	1866	1753	1496	1506	1284	1482	1712
Non-exp	EY/SEO	3792	3836	3698	3428	3093	2900	3111	3389	3266	2848	2918	2508	2858	3115
Biom.based	BS	2905	3392	3188	3484	3084	2873	3206	968	868	2885	2873	1485	1563	2017
Biom.based	AI	2431	2366	2585	2224	2088	1986	1495	1897	2460	1736	1719	1643	2821	3156
Biom.based	WG	2255	3464	2490	1554	1778	2043	1426	2190	1929	1167	1734	1012	1775	1616
Biom.based	CG	7997	6189	6495	5392	5292	4461	4619	7297	5947	4153	3635	3703	3585	4704
Biom.based	WY	2216	1701	2071	1933	1386	1337	2105	1958	1542	1193	1188	1655	1627	1718
Biom.based	EY/SEO	3195	3888	3270	3442	2451	2531	3188	2940	3484	2588	2508	2297	2138	2169
Exp.Fish.wt	BS	2469	2621	2730	2555	2497	2878	2461	2517	1991	1711	1833	2074	2136	2474
Exp.Fish.wt	AI	3030	2846	2644	2530	2359	2130	2044	2264	2075	1790	2016	1688	2072	2276
Exp.Fish.wt	WG	1760	1810	1933	1743	1397	1378	1449	1534	1513	1257	1168	1000	1142	1235
Exp.Fish.wt	CG	5901	6140	5625	4974	4341	3874	4295	4526	4562	3861	3387	2719	3047	3558
Exp.Fish.wt	WY	2721	2599	2396	2006	1700	1593	1970	2114	2002	1626	1678	1316	1579	1778
Exp.Fish.wt	EY/SEO	5119	4983	4772	4222	3786	3378	3821	4295	4087	3477	3574	2998	3533	4060
Exp.Surv.wt	BS	2810	3143	3098	3126	2939	2839	3097	2168	1453	2055	2464	1753	1785	2100
Exp.Surv.wt	AI	2833	2592	2533	2249	2028	1952	1783	1904	2129	1768	1723	1572	2328	2891
Exp.Surv.wt	WG	2666	3071	2696	1994	1758	1881	1683	1979	1908	1400	1544	1187	1564	1682
Exp.Surv.wt	CG	7505	6844	6537	5634	5177	4641	4768	6199	5905	4557	4083	3664	3867	4523
Exp.Surv.wt	WY	2004	1835	1925	1827	1519	1376	1788	1943	1674	1305	1262	1366	1588	1759
Exp.Surv.wt	EY/SEO	3181	3516	3310	3200	2659	2541	2921	3056	3160	2636	2580	2252	2378	2425
Mature.appt	BS	2128	2078	2172	2152	1735	1533	1466	1238	996	1025	1236	1277	1461	1456
Mature.appt	AI	1704	1619	1547	1367	1224	1281	1402	1506	1412	1177	1153	1034	1469	1962

Mature.appt	WG	2268	2319	2140	1699	1384	1468	1413	1519	1517	1230	1173	991	1218	1426
Mature.appt	CG	10432	10347	9574	8259	7394	6635	6726	7350	6875	5468	5255	4471	4615	5205
Mature.appt	WY	2068	2118	2166	2065	2009	1966	2414	2713	2561	2125	2036	1641	1953	2312
Mature.appt	EY/SEO	6302	6339	5924	5124	4765	4442	4850	5504	5250	4152	3881	3132	3382	3958
Exp.Mature	BS	2087	1994	2375	2521	1555	1161	993	913	1260	1367	1597	1474	1156	985
Exp.Mature	AI	1599	1432	1443	1418	1413	1438	1383	1387	1337	1205	1235	1082	1834	2415
Exp.Mature	WG	1994	2335	2095	1380	1302	1559	1494	1620	1388	1081	1215	979	1420	1476
Exp.Mature	CG	10610	10004	9108	7810	7415	6538	6346	7407	6785	5307	4905	4127	4207	5346
Exp.Mature	WY	2325	2310	2270	2175	2106	2150	2878	2840	2406	1872	1805	1743	2181	2469
Exp.Mature	EY/SEO	2385	2925	2809	2727	2290	2385	2946	3083	3054	2890	2900	2391	2710	2690
RandomEffects	BS	2906	3381	3207	3460	3078	2875	3226	986	860	2839	2880	1487	1570	2017
RandomEffects	AI	2453	2364	2585	2221	2082	1985	1518	1903	2426	1737	1718	1643	2781	3158
RandomEffects	WG	2278	3422	2517	1563	1765	2033	1448	2188	1922	1170	1719	1021	1763	1624
RandomEffects	CG	7975	6289	6451	5436	5259	4490	4628	7182	6014	4181	3653	3697	3603	4662
RandomEffects	WY	2198	1719	2053	1930	1398	1336	2080	1986	1549	1191	1187	1631	1633	1725
RandomEffects	EY/SEO	3191	3825	3287	3420	2498	2511	3139	3005	3459	2603	2500	2317	2159	2195

Appendix 2. Proportion of ABC by area and year, for each 'retrospective' apportionment type.

Apportionment method:	Area	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Status quo	BS	0.13	0.14	0.15	0.16	0.17	0.19	0.18	0.13	0.10	0.14	0.17	0.16	0.14	0.14
Status quo	AI	0.14	0.13	0.13	0.13	0.13	0.13	0.12	0.12	0.13	0.13	0.13	0.14	0.17	0.17
Status quo	WG	0.11	0.13	0.12	0.11	0.10	0.11	0.10	0.11	0.11	0.10	0.10	0.10	0.11	0.10
Status quo	CG	0.33	0.31	0.31	0.30	0.30	0.29	0.29	0.33	0.34	0.32	0.28	0.28	0.27	0.27
Status quo	WY	0.11	0.10	0.10	0.10	0.10	0.10	0.12	0.12	0.11	0.10	0.10	0.11	0.12	0.11
Status quo	EY/SEO	0.18	0.19	0.19	0.20	0.19	0.19	0.20	0.20	0.21	0.21	0.21	0.21	0.20	0.19
Static	BS	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Static	AI	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
Static	WG	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
Static	CG	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34
Static	WY	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
Static	EY/SEO	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21
Equal	BS	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17
Equal	AI	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17
Equal	WG	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17
Equal	CG	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17
Equal	WY	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17
Equal	EY/SEO	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17
Equilibrium	BS	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
Equilibrium	AI	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14
Equilibrium	WG	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
Equilibrium	CG	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27
Equilibrium	WY	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14
Equilibrium	EY/SEO	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23
Part.fixed	BS	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Part.fixed	AI	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Part.fixed	WG	0.12	0.14	0.13	0.12	0.12	0.13	0.11	0.11	0.11	0.11	0.12	0.11	0.12	0.12

Part.fixed	CG	0.36	0.34	0.34	0.34	0.35	0.34	0.33	0.35	0.35	0.35	0.32	0.32	0.31	0.32
Part.fixed	WY	0.12	0.11	0.11	0.12	0.11	0.11	0.13	0.12	0.11	0.11	0.12	0.13	0.14	0.13
Part.fixed	EY/SEO	0.20	0.21	0.21	0.22	0.22	0.22	0.23	0.22	0.22	0.23	0.24	0.24	0.24	0.23
Non-exp	BS	0.13	0.14	0.14	0.15	0.16	0.17	0.18	0.16	0.14	0.14	0.14	0.14	0.14	0.16
Non-exp	AI	0.15	0.14	0.14	0.13	0.13	0.13	0.13	0.12	0.13	0.12	0.13	0.13	0.15	0.16
Non-exp	WG	0.12	0.13	0.12	0.11	0.11	0.11	0.10	0.10	0.11	0.10	0.10	0.10	0.10	0.10
Non-exp	CG	0.31	0.32	0.32	0.31	0.31	0.29	0.29	0.31	0.32	0.31	0.31	0.31	0.28	0.27
Non-exp	WY	0.10	0.10	0.10	0.10	0.10	0.10	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
Non-exp	EY/SEO	0.18	0.18	0.18	0.19	0.19	0.19	0.19	0.20	0.20	0.21	0.21	0.21	0.21	0.20
Biom.based	BS	0.14	0.16	0.16	0.19	0.19	0.19	0.20	0.06	0.05	0.21	0.21	0.13	0.12	0.13
Biom.based	AI	0.12	0.11	0.13	0.12	0.13	0.13	0.09	0.11	0.15	0.13	0.13	0.14	0.21	0.21
Biom.based	WG	0.11	0.16	0.12	0.09	0.11	0.13	0.09	0.13	0.12	0.09	0.13	0.09	0.13	0.11
Biom.based	CG	0.38	0.29	0.32	0.30	0.33	0.29	0.29	0.42	0.37	0.30	0.27	0.31	0.27	0.31
Biom.based	WY	0.11	0.08	0.10	0.11	0.09	0.09	0.13	0.11	0.09	0.09	0.09	0.14	0.12	0.11
Biom.based	EY/SEO	0.15	0.19	0.16	0.19	0.15	0.17	0.20	0.17	0.21	0.19	0.18	0.19	0.16	0.14
Exp.Fish.wt	BS	0.12	0.12	0.14	0.14	0.16	0.19	0.15	0.15	0.12	0.12	0.13	0.18	0.16	0.16
Exp.Fish.wt	AI	0.14	0.14	0.13	0.14	0.15	0.14	0.13	0.13	0.13	0.13	0.15	0.14	0.15	0.15
Exp.Fish.wt	WG	0.08	0.09	0.10	0.10	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.08	0.08	0.08
Exp.Fish.wt	CG	0.28	0.29	0.28	0.28	0.27	0.25	0.27	0.26	0.28	0.28	0.25	0.23	0.23	0.23
Exp.Fish.wt	WY	0.13	0.12	0.12	0.11	0.11	0.10	0.12	0.12	0.12	0.12	0.12	0.11	0.12	0.12
Exp.Fish.wt	EY/SEO	0.24	0.24	0.24	0.23	0.24	0.22	0.24	0.25	0.25	0.25	0.26	0.25	0.26	0.26
Exp.Surv.wt	BS	0.13	0.15	0.15	0.17	0.18	0.19	0.19	0.13	0.09	0.15	0.18	0.15	0.13	0.14
Exp.Surv.wt	AI	0.13	0.12	0.13	0.12	0.13	0.13	0.11	0.11	0.13	0.13	0.13	0.13	0.17	0.19
Exp.Surv.wt	WG	0.13	0.15	0.13	0.11	0.11	0.12	0.10	0.11	0.12	0.10	0.11	0.10	0.12	0.11
Exp.Surv.wt	CG	0.36	0.33	0.33	0.31	0.32	0.30	0.30	0.36	0.36	0.33	0.30	0.31	0.29	0.29
Exp.Surv.wt	WY	0.10	0.09	0.10	0.10	0.09	0.09	0.11	0.11	0.10	0.10	0.09	0.12	0.12	0.11
Exp.Surv.wt	EY/SEO	0.15	0.17	0.16	0.18	0.17	0.17	0.18	0.18	0.19	0.19	0.19	0.19	0.18	0.16
Mature.appt	BS	0.10	0.10	0.11	0.12	0.11	0.10	0.09	0.07	0.06	0.07	0.09	0.11	0.11	0.09
Mature.appt	AI	0.08	0.08	0.08	0.08	0.08	0.08	0.09	0.09	0.09	0.09	0.08	0.09	0.11	0.13
Mature.appt	WG	0.11	0.11	0.11	0.09	0.09	0.10	0.09	0.09	0.09	0.09	0.09	0.08	0.09	0.09
Mature.appt	CG	0.50	0.49	0.48	0.46	0.46	0.44	0.42	0.43	0.42	0.40	0.38	0.38	0.34	0.34

Mature.appt	WY	0.10	0.10	0.11	0.11	0.12	0.13	0.15	0.16	0.16	0.15	0.15	0.14	0.14	0.15
Mature.appt	EY/SEO	0.11	0.12	0.12	0.14	0.15	0.15	0.16	0.17	0.18	0.20	0.21	0.20	0.21	0.20
Exp.Mature	BS	0.10	0.09	0.12	0.14	0.10	0.08	0.06	0.05	0.08	0.10	0.12	0.12	0.09	0.06
Exp.Mature	AI	0.08	0.07	0.07	0.08	0.09	0.09	0.09	0.08	0.08	0.09	0.09	0.09	0.14	0.16
Exp.Mature	WG	0.09	0.11	0.10	0.08	0.08	0.10	0.09	0.09	0.09	0.08	0.09	0.08	0.11	0.10
Exp.Mature	CG	0.51	0.48	0.45	0.43	0.46	0.43	0.40	0.43	0.42	0.39	0.36	0.35	0.31	0.35
Exp.Mature	WY	0.11	0.11	0.11	0.12	0.13	0.14	0.18	0.16	0.15	0.14	0.13	0.15	0.16	0.16
Exp.Mature	EY/SEO	0.11	0.14	0.14	0.15	0.14	0.16	0.18	0.18	0.19	0.21	0.21	0.20	0.20	0.17
RandomEffects	BS	0.14	0.16	0.16	0.19	0.19	0.19	0.20	0.06	0.05	0.21	0.21	0.13	0.12	0.13
RandomEffects	AI	0.12	0.11	0.13	0.12	0.13	0.13	0.09	0.11	0.15	0.13	0.13	0.14	0.21	0.21
RandomEffects	WG	0.11	0.16	0.13	0.09	0.11	0.13	0.09	0.13	0.12	0.09	0.13	0.09	0.13	0.11
RandomEffects	CG	0.38	0.30	0.32	0.30	0.33	0.29	0.29	0.42	0.37	0.30	0.27	0.31	0.27	0.30
RandomEffects	WY	0.10	0.08	0.10	0.11	0.09	0.09	0.13	0.12	0.10	0.09	0.09	0.14	0.12	0.11
RandomEffects	EY/SEO	0.15	0.18	0.16	0.19	0.16	0.16	0.20	0.17	0.21	0.19	0.18	0.20	0.16	0.14