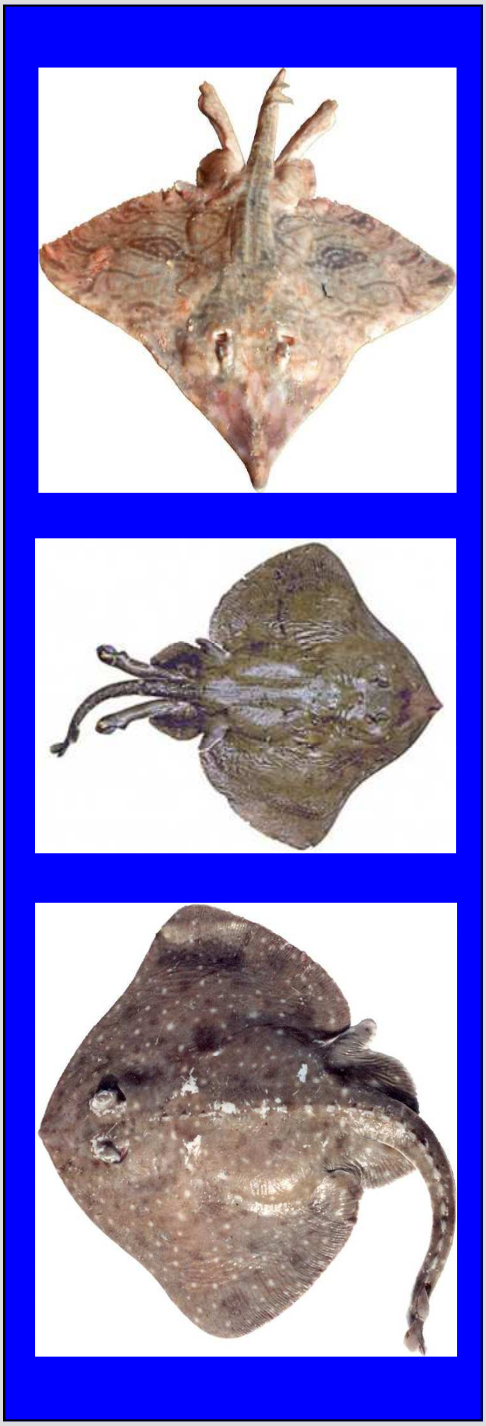


Stock assessment

Skates

(Rajidae)

Andreas Winter

Natural Resources
Fisheries
May 2018

Index

Summary

1. In 2017, skate catch by skate-licensed trawlers was reported at 1135.9 tonnes, out of a total skate catch (all fisheries) of 3200.0 tonnes. Both the total skate catch and total skate-license effort in 2017 were the lowest since 1998. Two Falklands-flagged vessels fished under skate license for the first time.
2. Stock assessment of the multi-species skate assemblage was calculated with a Schaefer production model. The model was optimized on CPUE indices of Korean and Spanish target trawl catches north of 51°S, with penalty functions for survey biomass estimates calculated in 2010 and 2013, carrying capacity $\geq$ initial biomass, and current biomass $>$ maximum sustainable yield.
3. The Schaefer production model estimated skate biomass north of 51°S in 2015 at 43,343 tonnes (95% confidence interval 32,049 to 88,776 tonnes) and maximum sustainable yield at 6,403 tonnes (95% confidence interval 5,537 to 43,655 tonnes).
4. Among the six predominant skate species, individual species CPUE time series showed increasing smoothed trends for *Bathyraja brachyurops* and *Zearaja chilensis*. CPUE time series were not significantly changing for *Bathyraja albomaculata*, *Bathyraja multispinis* and *Bathyraja scaphiops*. The CPUE smoothed trend for *Bathyraja griseocauda* was decreasing through 2017, but with indications of increase in the three most recent years.

Introduction

Skate catches (Rajiformes) have been reported in Falkland Islands waters since 1987. Skate catches were low until the stocks were commercially recognized by a Korean trawl fleet in the early 1990s (Wakeford et al. 2005), but rapidly increased >5000 tonnes year^{-1}. Given the strong targeted effort, skate trawling was licensed separately from other trawl fisheries starting in 1994 (Wakeford et al. 2005). Two skate fishing regions were identified: north and south of the Falkland Islands, and the southern region soon showed signs of decreasing catch (Agnew et al. 2000; Wakeford et al. 2005). As a conservation measure, directed fishing for skates was prohibited south of 51°S in 1996 (Agnew et al. 1999).

Directed fishing for skates in the north has continued annually. In 2017, skate catch by skate (F) licensed trawlers was 1135.9 tonnes (Table 1), taken in 29 grid units north of 51 °S (Figure 1). Of these 29 grid units, 6 grid units (XHAK, XKAP, XJAP, XHAL, XEAH, XDAH) yielded >85 tonnes each, accounting for 63.9% of skate catch as well as 55.6% of skate-license effort (Figure 1). Skate bycatch by other commercial bottom trawls (licensed for finfish or Falkland calamari) was 1345.7 tonnes, taken in 138 grid units around the Falkland Islands. Of these 138 grid units, 22 were among the 29 grid units that had also been fished with skate license; and these accounted for 34.8% of the skate catch by other commercial bottom trawls. Of the total skate bycatch by other commercial bottom trawls, 25.7% was taken by vessels that had also held skate licenses during the year, while representing 15.1% of the effort. Additionally 27.7 tonnes of skate in 2017 were taken as bycatch under longline (L) license, and 7.1 tonnes under *Illex* (B) license. No skate bycatch was taken under surimi (S) license. Total experimental (E) license catch of skate in 2017 was 8.4 tonnes.

FIFD observers sampled 27617 skates on 21 fishing vessels in 2016, over a total of 176 sample stations. Sixteen skate species were identified, representing most of the known species in Falkland Islands waters (Arkhipkin et al. 2012). By weight, 30.3% of skate samples were *Bathyraja brachyurops*, 18.6% *Bathyraja albomaculata*, 13.7% *Bathyraja griseocauda*, 10.7% *Zearaja chilensis*, 7.8% *Bathyraja cousseauae*, 4.9% *Bathyraja macloviana*, 4.3% *Bathyraja scaphiops*, 4.3% *Bathyraja multispinis*, 3.9% *Amblyraja* *doellojuradoi*, 0.5% *Amblyraja cf. georgiana*, 0.2% *Psammobatis* spp., 0.2% *Dipturus argentinensus*, 0.2% *Dipturus trachydermus*, 0.2% *Bathyraja papilionifera*, 0.1% *Bathyraja meridionalis*, and <0.1% *Bathyraja magellanica*.

Stock assessment for license allocation was again based on the multi-species skate complex, as species are not identified in vessel catch reports (Agnew et al. 2000, Wakeford et al. 2005, Winter et al. 2015). However, annual CPUE trends are reported for six major species of interest (Winter et al. 2015).

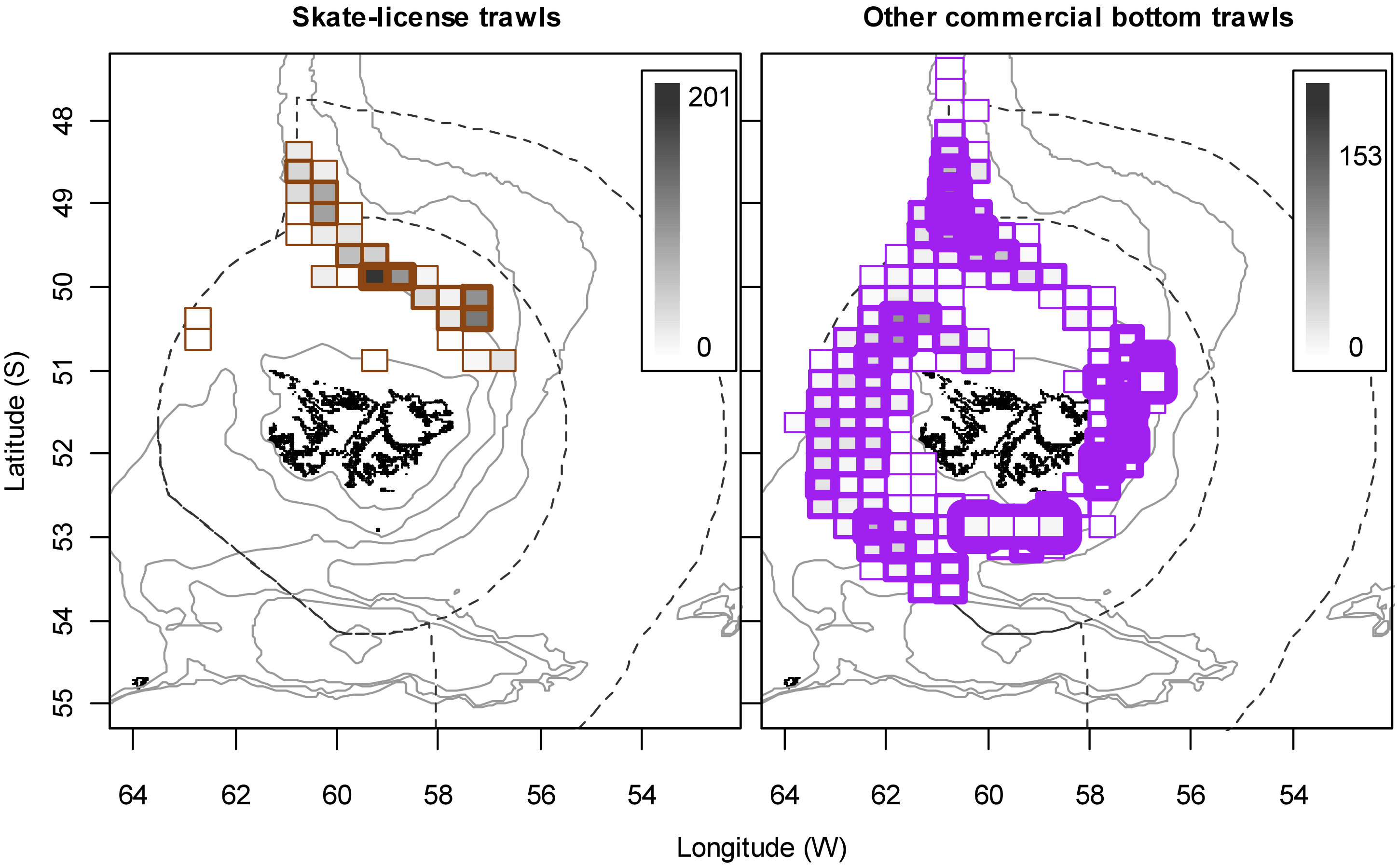


Figure 1. Distribution of skate catches by grid under skate license (left) and other bottom-trawl licenses (right) in 2017. Thickness of grid lines is proportional to the number of vessel-days (1 to 20 for skate license, left; 1 to 320 for other bottom-trawl licenses, right). Gray-scale is proportional to the skate catch biomass (maximum 200.5 tonnes in one grid unit for skate license, left; maximum of 152.8 tonnes for other bottom-trawl licenses, right).

Methods

The skate stock assessment was updated with the most recent year's catch and effort report data. All skate catches from all years are entered according to the revised conversion factors (Winter and Pompert 2014). The current skate stock assessment was calculated as a Schaefer production model (Schaefer 1954), expressed as a difference equation:

$$B_{t+1} = B_t + rB_t\left(1 - \frac{B_t}{K}\right) - C_t$$

where B_t and C_t are the stock biomass and catch in year t; r is the intrinsic population growth rate and K is the carrying capacity. The Schaefer production model was optimized on time series of standardized commercial CPUE as indices of relative abundance. Since 2016 (Winter 2016), the Schaefer production model has been optimized on an objective function comprising the negative log-likelihood functions of both Korean and Spanish skate-license CPUE trawl indices north of 51°S:

$$\mathrm{L}\{\mathrm{CPUE}_{Korea\ N}, \mathrm{CPUE}_{Spain\ N} \mid \text{parameters}\} \quad =$$

$$\mathrm{L}\{\mathrm{CPUE}_{Korea\ N} \mid \mathrm{K}, \mathrm{B}_1, \mathrm{r}, \mathrm{q}_{Korea\ N}\} \;+\; \mathrm{L}\{\mathrm{CPUE}_{Spain\ N} \mid \mathrm{K}, \mathrm{B}_1, \mathrm{r}, \mathrm{q}_{Spain\ N}\}$$

where

$$\mathrm{L}\{\mathrm{CPUE}_{Korea\ N} \mid \mathrm{K}, \mathrm{B}_1, \mathrm{r}, \mathrm{q}_{Korea\ N}\} \quad =$$

$$\mathrm{n}\left(\log(\sigma_{Korea\ N}) + \frac{\log(2\pi)}{2}\right) + \frac{\sum_t\left(\log(\mathrm{B}_t) - \log(\mathrm{CPUE}_{Korea\ N\,\mathrm{t}} / \mathrm{q}_{Korea\ N})\right)^2}{2\sigma^2_{Korea\ N}}$$

Equivalently, substitute *Spain N* for *Korea N*; notation following Hilborn and Mangel (1997); n is the length of time series t observations, q is the catchability coefficient of the CPUE index expressed as kg of skate catch per trawl hour, and σ is the standard deviation between $\log(B_t)$ and $\log(CPUE_t / q_t)$:

$$\sigma_{Korea\ N} \quad = \quad \sqrt{\overline{\left(\log(\mathrm{B}_t) - \log(\mathrm{CPUE}_{Korea\ N\,\mathrm{t}} / \mathrm{q}_{Korea\ N})\right)^2}}$$

CPUE $_{Korea\ N}$ and CPUE $_{Spain\ N}$ were standardized for latitude, longitude, month and depth using generalized additive models (GAM) with a log link function. Annual skate catch and effort data from 1989 through 2017 were included. Skate licenses have been implemented since 1994 (Wakeford et al. 2005), and a probabilistic algorithm (FIFD 2013) was used to infer which Korean trawls were actually targeting skates in the years 1989 to 1993, before the issuance of skate licenses. The two earliest years 1987 and 1988 were not included because catch reporting did not yet distinguish trawls from jigging or longline. The same probabilistic assignment of 1989 to 1993 Korean skate target trawls as previously (Winter 2017) was applied to the current assessment. The probabilistic algorithm was not calculated to infer Spanish trawls targeting skates in 1989 to 1993, because in the following years 1994 to 1996, which are used as the template, only 12 days of skate license trawling were taken by a single Spanish vessel (during 1995).

Biomass in the first year of the fishery ($B_1 = B_{1989}$) was optimized as a free parameter in the Schaefer production model. B_1 is sometimes assumed to equal the carrying capacity K (Punt 1990, Hilborn and Mangel 1997, Maunder 2001), and this assumption has previously been employed for the Falkland Islands skate fishery (Agnew et al. 2000). However, skate catches in Falkland Islands waters have been taken since before 1989 (FIG 1989). For this assessment, K and B_1 were therefore optimized separately along with r, $q_{Korea\ N}$, and $q_{Spain\ N}$.

Four penalty terms were added to the Schaefer production model to stabilize the optimization. The first two penalty terms related to skate biomass estimates from FIFD skate surveys conducted in 2010 (Arkhipkin et al. 2010) and 2013 (Pompert et al. 2014). In either survey the 26 grid units were occupied that represented the historic concentration of the skate target fishery (Payá et al. 2008). Because the commercial fishery can shift around in any year, the inference was made that the proportion of total commercial skate catch taken in the top 26 grids (not necessarily the exact same ones) should reflect the ratio of survey area biomass to total biomass north of 51 °S (Laptikhovsky et al. 2011). Survey area biomasses in 2010 and 2013 were estimated from swept-area samples with variability distributions calculated by bootstrap re-sampling (Arkhipkin et al. 2010, Pompert et al. 2014). The proportions of total commercial skate catch taken in the top 26 grids in 2010 and 2013 likewise had variability distributions calculated by bootstrap re-sampling. Combining the two variability distributions, composite estimates of total skate biomass had 95% confidence limits of:

2010	17,832.7 to 50,198.3 tonnes
2013	14,494.1 to 82,840.4 tonnes

The penalty function was implemented as the log squared difference:

$$\mathrm{P}\{\mathrm{B}_{survey\ 2010}, \mathrm{B}_{2010} \,|\, \mathrm{K}, \mathrm{B}_1, \mathrm{r}, \mathrm{q}_{Korea\ N}\} =$$

$$\emptyset \frac{\left(\log\left(\mathrm{B}_{survey\ 2010\ min\ /\ max\ 95\%}\right) - \log(\mathrm{B}_{2010})\right)^2}{2\sigma^2_{Korea\ N}}$$

where $\emptyset = 0$ if the B_{2010} iteration of the optimization was within the 95% confidence limits of the 2010 survey estimate, and $\emptyset = 1$ if the B_{2010} iteration was outside the 95% confidence limits of the 2010 survey estimate. (Again, equivalently substitute *Spain N* for *Korea N*, and / or survey 2013 for survey 2010). The third penalty term was for $\mathrm{K} \geq \mathrm{B}_1$ (Prager 1994), and the fourth penalty term was for $\mathrm{B}_{2015} \geq$ maximum sustainable yield (MSY). The third and fourth penalty terms were likewise calculated as log squared differences and triggered by multipliers $\emptyset = 0$ or 1 according to whether the condition was met.

The Schaefer production model was optimized in R programming code with a Nelder-Mead algorithm, on both Korean and Spanish CPUE indices and the four penalty functions. The larger number of Korean data automatically gave greater weight to the Korean index. To estimate parameter variability the model was run though a Markov Chain Monte Carlo (MCMC) with 5×10^6 iterations of which the first 20,000 were discarded as burn-in, and every tenth iteration was retained to mitigate autocorrelation. The set of 498,000 retained MCMC iterations was used to generate 95% confidence intervals for each of the optimization parameters K, B_1, r, $\mathrm{q}_{Korea\ N}$ and $\mathrm{q}_{Spain\ N}$, and for MSY calculated as (Hilborn and Walters 1992):

$$\mathrm{MSY} = \frac{\mathrm{rK}}{4}.$$

The assessment of total skate biomass can potentially mask changes in assemblage composition, with species more vulnerable to fishing pressure replaced by more resilient species (Dulvy et al. 2000, Ruocco et al. 2012). Species composition trends in the Falkland Islands skate fishery have been examined by Agnew et al. (2000), Wakeford et al. (2005), and Winter et al. (2015). For the current stock assessment, CPUE time-series trends were updated and examined for the six species of interest described in Winter et al. (2015): *B. albomaculata*, *B. brachyurops*, *Z. chilensis*, *B. griseocauda*, *B. multispinis* and *B. scaphiops*.

Skate species CPUE were calculated from all trawl stations under skate license (or inferred to be skate-targeting prior to 1994; FIFD 2013), north of 51°S, that had observer reports of catch by species. CPUE trends were calculated according to methods slightly simplified from Winter et al. (2015), with CPUE per station standardized for latitude, longitude, month, depth and nation (Korea or Spain), and the inter-annual trends smoothed using locally-weighted regression (LOESS). Standardizations were calculated with generalized additive models (GAM), and because of the frequent occurrence of zero CPUE for species in various observer reports, a delta approach was used of fitting GAMs separately to positive (non-zero) CPUEs, with lognormal error distribution, and to the probability of occurrence (presence/absence) of positive CPUEs, with binomial error distribution (Pennington 1983). LOESS were calculated with degree = 1, span = 0.666, and weighted in proportion to the duration of each trawl station. Variability of the trends was estimated by randomly resampling with replacement the yearly stations and recalculating the LOESS for each resample. Resampling was iterated 5000× for each species. In several (particularly early) years, some stations recorded various amounts of both identified skate species and the unidentified code 'RAY'. For these stations the unidentified RAY was then assigned to the identified species as the lesser of either the proportion of identified species among themselves or the ratio of each identified species to the unidentified RAY. The latter option was mainly to prevent large amounts of unidentified RAY being assigned to single identified species at a station. For variability estimation, stations with both identified skate species and RAY were additionally randomized at each iteration by setting the proportional assignment for an identified species to a random uniform draw between zero and 2× the ratio of the identified species to the unidentified RAY (up to a maximum of the total amount of unidentified RAY). Stations that reported only RAY and no identified skate species were excluded altogether as it would be incorrect to record these as having zero catch of any one skate species. 95% confidence intervals (2.5% to 97.5%; Buckland 1984) were calculated from the 5000 random iterations weighted in proportion to each iteration's correlation between its standardized and unstandardized CPUE, with the weight factor capped at the standardized / unstandardized correlation of the empirical (i.e., original non-randomized) data. CPUE trends were evaluated against the criterion that statistically significant change would be indicated by a horizontal line intersecting the lower and upper 95% confidence intervals (Swartzman et al. 1992).

Results

Skate catch north of 51°S was 2481.6 tonnes in 2017, the lowest since 1998. In particular, skate target catch was the lowest since 1998 (Table 1), while skate non-target catch north was the lowest since 2008 (Table 1). Total skate catch in 2018 (3200.0 t) was likewise the lowest since 1998 (Figure 2), including a (non-target) catch south of 51°S that was the lowest since 2014 and third-lowest of the past 10 years, as commercial targets in the trawl fishery have shifted. The proportion of target skate catch vs. total skate catch (north and south) was 35.5% in 2016, slightly higher than last year and median for the past 5 years. Both the Korean target trawl standardized CPUE and Spanish target trawl standardized CPUE decreased sharply in 2017, the Korean CPUE to the lowest level since 2008 and the Spanish CPUE to the lowest level since 1995 (Figure 2, Table 1).

The decreases correlated with much of the fishing grounds having been closed in 2017 because of high bycatches of hake. These closures applied to finfish (A, G and W) licenses as well as skate target license, but as skate are largely taken as finfish bycatch the

Table 1. For the fishery north of 51°S latitude*, yearly total skate catches under target license (F/R), yearly total skate catches under other licenses, and standardized skate CPUE index of Korean and Spanish target trawls. Skate target and non-target licenses were not discriminated before 1994.

Year	Catch (tonnes)		CPUE (t/hr)	
	target	non-target	Korean target trawl	Spanish target trawl
1989	814.19		0.32	-
1990	787.03		0.45	-
1991	5806.63		0.37	-
1992	3314.25		0.25	-
1993	5465.51		0.27	-
1994	2186.32	1932.34	0.33	-
1995	3623.42	862.35	0.29	0.10
1996	1927.08	791.01	0.22	-
1997	1976.42	593.86	0.32	-
1998	226.63	396.65	0.41	-
1999	3467.83	418.36	0.36	-
2000	2511.36	549.27	0.31	-
2001	3406.68	542.33	0.38	-
2002	2194.42	497.02	0.41	-
2003	3137.54	480.47	0.41	-
2004	3881.38	478.84	0.41	-
2005	4396.01	595.65	0.49	-
2006	2711.47	1230.54	0.48	-
2007	3527.83	1303.38	0.60	0.37
2008	2280.21	1073.92	0.52	0.33
2009	2932.08	1922.43	0.57	0.47
2010	2725.08	2063.33	0.62	0.38
2011	2572.93	2853.60	0.54	0.29
2012	3094.04	2409.87	0.70	0.34
2013	2223.73	2510.27	0.56	0.34
2014	2953.40	2155.88	0.61	0.73
2015	2365.28	3222.47	0.69	0.31
2016	2125.59	2121.64	0.75	0.35
2017	1135.89	1345.74	0.52	0.13

* Skate-license fishing has been restricted to north of 51°S latitude since 1996. Target catches before 1996, and non-target catches before and since 1996 are thus not total catches of skate.

effect is compounded in all trawl fisheries. Skate license fishing effort was the lowest in 2017 by Korean vessels since 1998; and the lowest by Spanish vessels since they re-entered the fishery in 2007. 2017 was also the first year ever that skate license effort was taken by Falklands-flagged vessels, following a transfer of quota. Two Falklands-flagged vessels took

24 fishing days under skate license (compared to 104 Korean fishing days and 5 Spanish fishing days). While Falklands-flagged trawlers operate as Spanish vessels, neither of these two had ever operated in the skate-license fishery before and were therefore not included with the Spanish CPUE index.

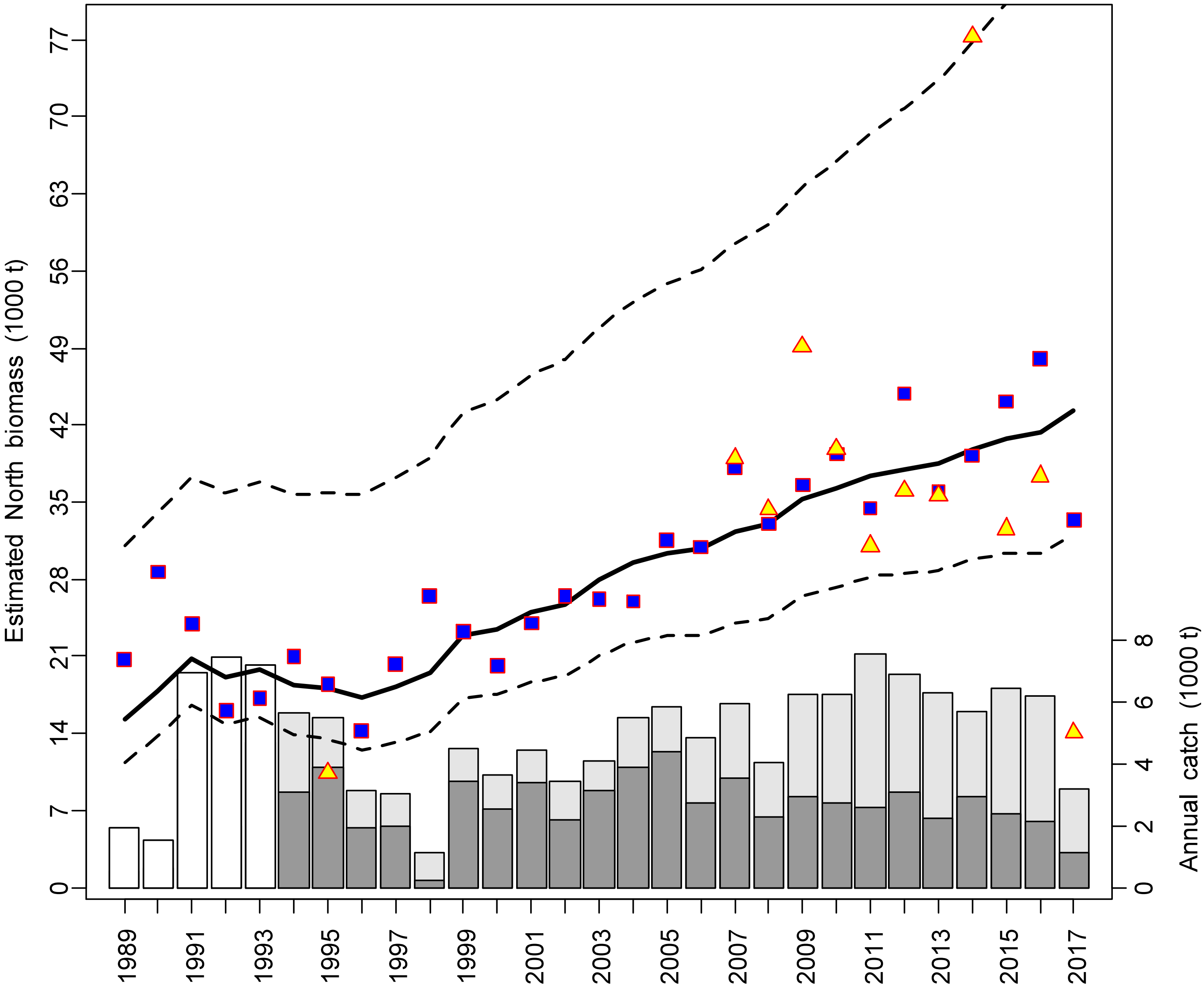


Figure 2. F/R-licensed skate catches (dark grey bars), non-target-licensed skate catches (light grey bars), indiscriminate license catches (white bars), estimated biomass of the northern skate stock ± 95% confidence intervals (black lines), and CPUE indices the biomass time series was optimized on: Korean target trawls (blue squares) and Spanish target trawls (yellow triangles). The figure is formatted for comparison with Figure 3A in Wakeford et al. (2005).

Production model fit parameters for total skate biomass north of 51 ºS are summarized in Table 2 together with their 95% confidence intervals from the MCMC. A similar outcome as in previous assessments was obtained: very wide bounding of the carrying capacity K and heavily right-skewed biomass estimates. The decreases in CPUE indices were not yet substantiated enough to inflect the optimization of biomass downwards (Figure 2). Thus the estimate of skate biomass for 2017 was 43,343 tonnes, and the corresponding maximum sustainable yield 6,403 tonnes. The ratio of catchability coefficients between Spanish and Korean vessels from joint model optimization (Table 2: 0.95 / 1.56 = 0.606) was similar to the estimate of 0.600 made after the 2013 skate survey (Pompert et al. 2014).

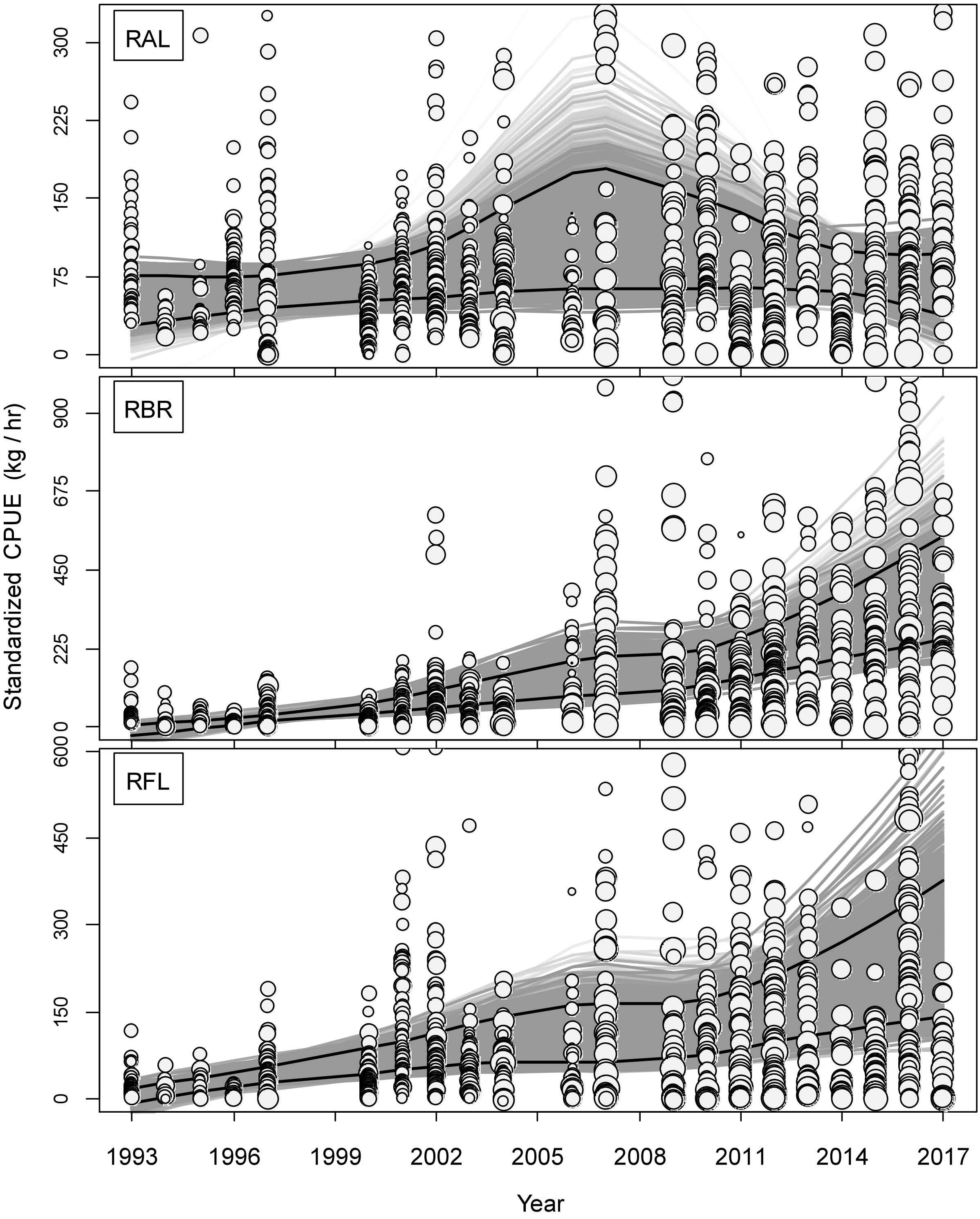
Table 2. Optimized Schaefer production model parameters obtained with the combination of Korean and Spanish target trawl CPUE indices, plus resulting estimates of year 2017 biomass north of 51 ºS latitude and MSY. 95% confidence intervals from MCMC iteration of the production model.

Parameter	CPUE target trawl indices	
	optimum	95% conf. interval
K	100,831	71,000 - 1,049,361
B_{1989}	15,337	11,402 - 31,087
r	0.254	0.125 - 0.324
q_{Korea}	$1.56\ e^{-5}$	$0.82\ e^{-5}$ - $2.07\ e^{-5}$
q_{Spain}	$0.95\ e^{-5}$	$0.48\ e^{-5}$ - $1.35\ e^{-5}$
B_{2017}	43,343	32,049 - 88,776
MSY	6,403	5,537 - 43,655

The time series of skate species catch data extended from 1993 to 2017, with data absent in years 1998, 1999, 2005 and 2008 (Table 3). A total of 1021 skate fishery observer stations were available over that time period, of which 35 in the most recent year 2017.

B. brachyurops (RBR) and *Z. chilensis* (RFL) continued the increasing CPUE trends that had been noted in Winter et al. (2015), albeit with higher variability in recent years (Figure 3). *B. brachyurops* and *Z. chilensis* were recorded in respectively 33 and 19 of the 35 skate fishery observer stations in 2017. *B. albomaculata* (RAL) showed some increase over the early part of the time series, but has levelled out over the past 5-6 years and in the current updated evaluation the trend was not significant. *B. albomaculata* was recorded in 34 of the 35 observer stations in 2017. *B. griseocauda* (RGR) presents the most concern as this species continues to be classified endangered (iucnredlist.org/details/63113/0). *B. griseocauda* was previously declining in Falkland Islands waters (Agnew et al. 2000, Wakeford et al. 2005) but reported stabilized by 2013 (Winter et al. 2015). The current LOESS trend is declining as the year 2014 in particular showed low CPUE, although the three years since 2014 CPUE have been higher (Figure 3). However, the *B. griseocauda* CPUE trend values for 2015 and 2016 are retrospectively higher from this year's time series computation than last year's (compare Table 3 with Table 3 in Winter 2017), indicative that this species is recently stabilizing again. *B. griseocauda* was recorded in 34 of the 35 observer stations in 2017. The two less abundant species *B. multispinis* (RMU) and *B. scaphiops* (RSC) had CPUE time series that were not significantly changing since 1993 (Figure 3), and both were recorded in 33 of the 35 observer stations in 2017.

Figure 3 [below]. Standardized CPUE by species estimated from observer trawl stations in the skate-license fishery, 1993 to 2016. Upper limit of each plot truncated at 95% or 99% of the data for visibility. Symbols are sized proportional to the duration of each trawl station. Grey lines: 5000 randomized iterations of the LOESS smooth through the time series; colour-scaled to the correlation between standardized and unstandardized CPUEs of each iteration. Black lines: weighted 95% confidence intervals of the randomized iterations.



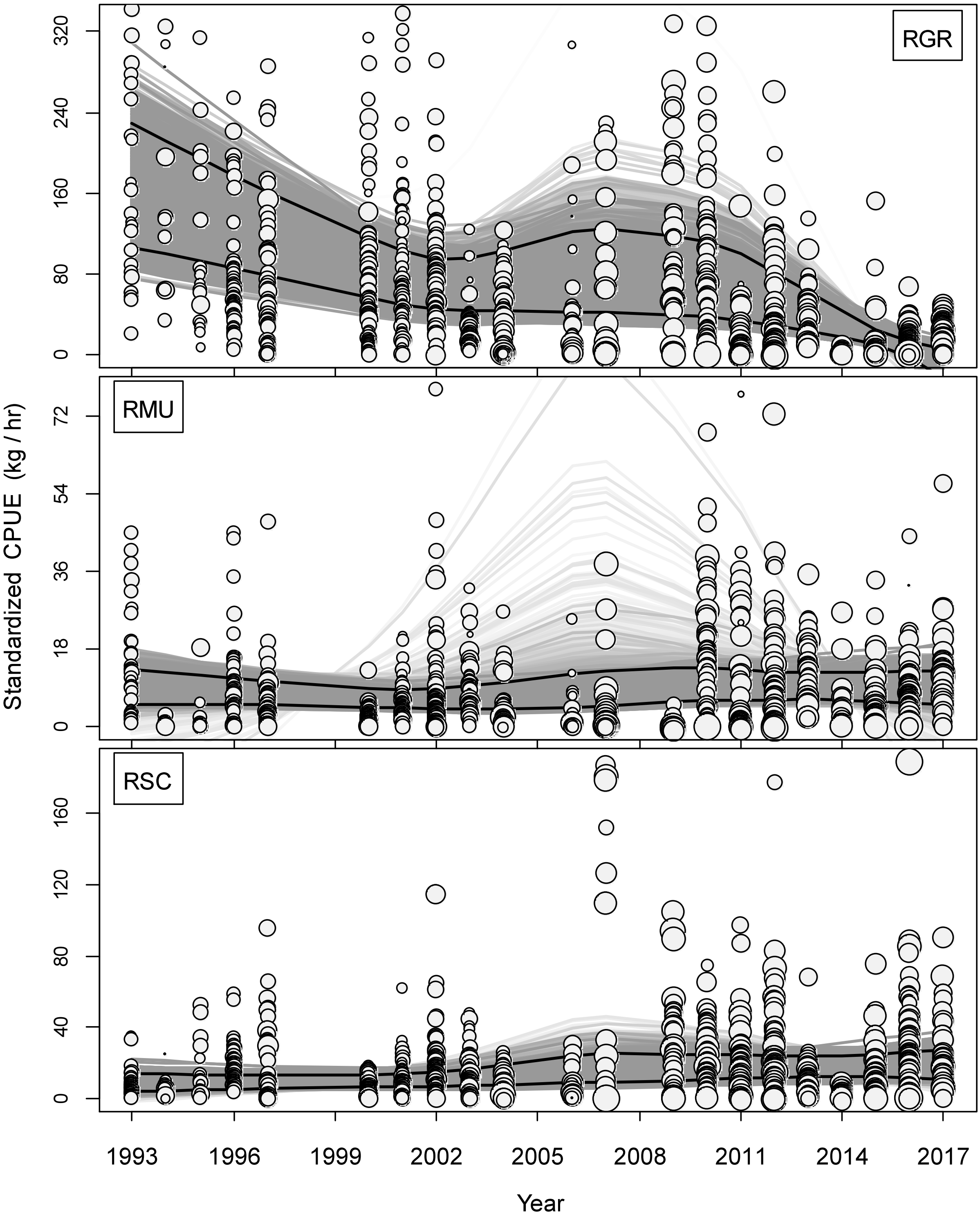


Table 3 [next page]. LOESS smooth values of standardized CPUE (kg hr^{-1}) per year per species from observer catch data; N = number of observer-sampled stations. LOESS smooth values correspond to the mid-range between 95% confidence intervals on Figure 3. Note that standardization (with residual error added back) can result in negative values. These were not corrected, to maintain the relative changes of the inter-annual trends.

Year	N	RAL	RBR	RFL	RGR	RMU	RSC
1989	0	-	-	-	-	-	-
1990	0	-	-	-	-	-	-
1991	0	-	-	-	-	-	-
1992	0	-	-	-	-	-	-
1993	35	53.7	–6.2	5.7	158.6	8.7	8.2
1994	11	55.1	1.4	14.0	147.5	8.3	8.3
1995	19	56.2	8.6	22.7	136.1	7.9	8.3
1996	53	58.1	16.8	31.1	125.3	7.6	8.5
1997	60	60.3	25.1	39.4	114.5	7.2	8.7
1998	0	-	-	-	-	-	-
1999	0	-	-	-	-	-	-
2000	76	69.1	52.6	62.5	83.1	6.2	9.5
2001	72	72.5	62.7	70.3	73.9	5.9	9.7
2002	69	76.6	74.2	78.8	67.7	5.7	9.9
2003	54	83.3	87.6	86.8	66.0	5.7	10.6
2004	57	90.9	101.8	93.3	67.6	5.9	11.5
2005	0	-	-	-	-	-	-
2006	29	104.2	126.3	97.8	71.1	6.4	13.9
2007	35	105.6	134.6	99.0	70.9	6.9	14.7
2008	0	-	-	-	-	-	-
2009	50	99.3	148.7	103.9	66.2	8.2	15.6
2010	57	96.2	165.1	112.9	63.1	8.6	16.1
2011	55	92.9	189.7	127.1	57.2	8.7	16.5
2012	70	87.6	215.5	141.9	47.7	8.8	16.7
2013	33	83.5	244.8	158.3	38.2	8.9	17.1
2014	29	79.1	274.7	174.4	28.2	8.8	17.5
2015	43	74.6	305.9	190.8	17.3	8.8	17.8
2016	79	71.0	339.0	208.0	6.2	8.6	18.1
2017	35	67.5	373.6	226.2	–4.4	8.4	18.4

Conclusions

Skate stock assessment for the year 2017 has tenuous status as the changing conditions of the fishery resulted in lower CPUE indices, but these lower indices do not yet weigh enough to influence the production-modelled inter-annual trend. Further, if the lower indices reflect areal shifts in the fishery rather than abundance, a more complex spatially heterogeneous modelling approach (Hilborn and Walters 1987, Kulka et al. 1996) may be required from now than can be accomplished by standardizing latitude and longitude. As well as shifts in the fishery, skate species themselves may be spatially segregated or locally migratory (Arkhipkin et al. 2008).

Smoothed CPUE time series for the six predominant skate species show trends that are increasing, stable, or indicative of increase in the past few years. The evidence of these individual species' time series is important as the use of combined CPUE indices for assessing the multi-species skate assemblage (Wakeford et al. 2005) remains a potential source of error. Maunder et al. (2006) and Kleiber and Maunder (2008) have noted that CPUE is not proportional to community abundance if q (catchability coefficient) is not similar for all species being combined. The species with the highest catchability may contribute a greater proportion to the combined CPUE, and represent the population that is most depleted. Accordingly, the analysis of individual species should be continued, with prioritization of observer coverage in skate target fisheries and in fisheries susceptible to catching quantities of skate.

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