Improved catch estimation for individual species in the BSAI skate complex

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Executive Summary

Skates in the Bering Sea and Aleutian Islands (BSAI) management area are managed as a single complex, and official catches are tracked at the complex level (i.e. a single skate catch record). Currently, trawl-survey species composition data are used to estimate catches of Alaska skates for use in the Alaska skate population model. These estimates are likely not entirely representative of commercial catches, particularly those from the longline fleet. Here, a new method is presented that applies species composition data from observed catches to the total skate catch data from the Catch Accounting System. The new method is an improvement over using survey data and should be used for estimating species-level skate catches in the BSAI. The new estimates of Alaska skate catch are slightly lower than the current estimates but had minimal effect on the population model. The new approach will also be useful for tracking the exploitation of species other than Alaska skate.

Description of the problem

In the Bering Sea and Aleutian Islands (BSAI) management area, skates are not targeted but are captured incidentally in large numbers. The majority of this incidental catch (80-90%) occurs in longline fisheries, particularly those targeting Pacific cod. Fishery observers aboard longline vessels conduct their species composition sampling primarily by watching the haulback of the longline and identifying and counting organisms as they emerge from the water and are brought up to the rail. This counting occurs during multiple discrete periods ("tally periods") that are designed to be representative of each longline haul. Because the observers cannot directly examine each organism, species that are hard to identify at a distance are recorded at coarser taxonomic groupings. During the tally period, a subset of the tallied species are set aside for species identification and weighing.

Skates in the BSAI occur in two main genera, *Bathyraja* and *Raja* (although big skate has recently been reclassified into its own genus *Beringraja*). Observers record these groups as soft snout skate and stiff snout skate, respectively. Stiff snout skates (longnose skate *Raja rhina* and big skate *Beringraja binoculata*) are relatively easy to identify visually to species and are often tallied as individual species. In contrast, soft snout skates are difficult to distinguish without examining features such as spine number and placement and only the subset of individuals that has been set aside for the observer are identified to species. The resulting species composition is not applied to the remaining tallied but unexamined skates, so the final catch composition data include a mix of species and the soft snout/stiff snout groups (Table 1). The majority (> 80%) of skate catches are recorded as soft snout skates.

An additional issue is that before the mid-2000s observers were not sufficiently trained in the identification of soft snout skates so even skates that were examined were mainly recorded as "skate unidentified". A concerted effort to enhance observer skate species identification was very successful and after 2007 almost all examined skates have been identified to species (Table 1).

The incomplete species composition data are carried into the official catch estimates from the Alaska Regional Office (AKRO) Catch Accounting System (CAS). Because the CAS relies heavily on observer data for species composition, species-level catch estimates are limited by the information in the observer database and the majority of BSAI skate catches are reported in the "other skate" category (Table 2). The AKRO does categorize catches for the more abundant skate species (Alaska, whiteblotched, Aleutian, big,

and longnose) but for the soft snout skates these records are incomplete. In addition because BSAI skates are managed as a complex with a single aggregate set of harvest specifications, catch accounting and public reporting of skate catches in the BSAI occurs for only one "unidentified skate" category.

Since 2008 an age-structured model has been used to assess Alaska skate, the most abundant skate species in the BSAI. This model requires species-specific catch estimates, and since 2008 an estimate of Alaska skate catches has been made by applying species composition data from the bottom trawl surveys to the CAS data in an area-stratified approach. While this method has been acceptable for the purposes of the model trawl-survey data, survey data are likely not entirely representative of commercial catches, particularly those from the longline fleet. In 2018 a new method for estimating skate catches was developed to (1) establish annual catch estimates for all skate species in the BSAI, and (2) improve the catch estimates used for the Alaska skate population model.

Methodology

The catch estimation methods described here rely on the primary assumption that the subset of skates that are set aside and examined during the tally period are representative of all skates counted during the tally period. This is similar to the general assumption that observer samples are representative of the entire haul. Following on this, for this analysis the "stiff snout" and "soft snout" categories are ignored and the resulting species-level catch reporting is used as the underlying species composition, which was then applied to the total skate catch. To overcome differences in observer sampling design and observer coverage, both data streams (observer species composition and CAS skate catch) were stratified by vessel type, gear type, and NMFS statistical area. The catch estimation involved 9 steps:

1) Haul-level catch data for all skate taxonomic categories (85-98, 159-168) were downloaded from the "Debriefed" tables in the OBSINT observer database for all years 2003-2017 (the current CAS began in 2003).

2) Catch data for all skate groups (700-705) were downloaded from the CAS for the years 2003-2017 (table V_CAS_TXN_PRIMARY_ALL).

3) For each year, data were first stratified by vessel type: catcher processor (CP) and catcher vessel (CV). Observer sampling differs between these vessel types; CPs also have full observer coverage while coverage for CVs is partial.

4) Data were then stratified by gear type: non-pelagic trawl, pelagic trawl, pot, and longline.

5) The CP and CV data were treated differently in regards to spatial stratification. Because CPs are full coverage, observer species composition data were available for all statistical areas where the CAS reported catches. In contrast, there was often a mismatch between CV data in this regard. As a result, CP data were stratified by vessel type/gear/type/statistical area while CV data were stratified only by vessel type/gear type.

6) Within each stratum, the extrapolated catch of each skate species was summed and the values were used to construct skate species proportions specific to that stratum.

7) These proportions were then multiplied by the total skate catch in the matching stratum from the CAS data.

8) The CP and CV data were merged to provide complete estimates of skate catch stratified by year, species, and gear type. Statistical area estimates are also available for CP data. The two trawl gear types were combined into a single category. In some years there was an extremely small amount

of skate catches in pots; to streamline the presentation while accounting for the total skate catch this was added to the trawl catch.

9) Catches in the "skate unidentified" category were apportioned to each remaining species group according to their proportion in the stratum.

Results

Overall results: The analysis yielded complete results for all species (Tables 3-6, Figures 2-4). During 2003-2006 the majority of skate catches were reported as "skate unidentified" (Table 3, Figure 2), but the proportion of skates in that category declined steadily from 2003-2011 so that in 2017 only 0.4% of skates were recorded as unidentified. To provide the best possible species-level estimate of catches, the "skate unidentified" catches were apportioned to each species according to their proportion in each stratum; however the species-level catches in years 2003-2006 should be viewed as having higher uncertainty due to the small number of skates identified to species.

Similar to estimates generated by the old approach Alaska skate makes up the vast majority of all catches, and catches for all major skate species have increased since 2011 (Tables 4-6, Figure 2). Most of this increase has occurred in longline fisheries (Figure 3). The species composition for each gear type is somewhat variable (Tables 4-6, Figure 4). Two notable trends are increasing proportions of big skate and particularly whiteblotched skate in trawl fisheries. The increase in big skate catches parallels increasing abundance in the southeastern Bering Sea. In contrast the abundance of whiteblotched skate is stable, so increased catches of that species may indicate a shift in the spatial distribution of trawl catches.

Alaska skate catch estimation, new versus old: Estimates of total Alaska skate catch using the new method are slightly lower than those produced using the existing methods (Figure 5). Except for 2017 the new estimates for longline fisheries are consistently lower than the current estimates. In contrast, for trawl catches the relationship between the two estimates has been variable. The lower estimates from the new methods in recent years (Figure 5) may reflect the change in species composition within the trawl data.

Effect of new catch estimates on the Alaska skate model: The model used in the 2016 assessment was re-run replacing the 2003-2016 data with the new catch estimates. The new data had a minimal effect on the model, slightly influencing reference point estimates and estimates of F (Table 7; differences in estimates of F were too small to be shown at the resolution in the table).

Conclusions

1) The methods for skate catch estimation presented here is a marked improvement over the existing method, and the new approach should be used for estimating Alaska skate catches used in the population model.

2) Although official skate catch is tracked only at the complex level, the species-level catches generated using the new method will be useful for discerning trends in catches of individual species. This will be particularly useful for identifying increases in exploitation rates.

3) Due to the severe lack of species identification in observer coverage before 2003, pre-2003 estimates of Alaska skate catch should continue to be made using the existing survey-based method. In addition estimates from 2003-2006, when most skates were not identified to species, should be used with caution.

Tables

Table 1. Proportions (by weight) of skate taxonomic groupings in observed longline catches in the Bering Sea and Aleutian Islands management area, 2014-2017. Highlighted rows indicate skates identified only to genus.

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taxonomic group	2014	2015	2016	2017
soft snout skate	0.813	0.830	0.839	0.864
Alaska skate	0.136	0.123	0.119	0.102
Bering skate	0.020	0.021	0.015	0.014
big skate	0.014	0.011	0.010	0.010
Aleutian skate	0.009	0.009	0.006	0.005
stiff snout skate	0.001	0.001	0.004	0.002
whiteblotched skate	0.002	0.002	0.002	0.001
Commander skate	0.002	0.001	0.001	0.001
skate unidentified	0.004	0.000	0.004	0.000
mud skate	0.000	0.000	0.000	0.000
whitebrow skate	0.000	0.000	0.000	0.000
skate egg case unidentified	0.000	0.000	0.000	0.000
longnose skate	0.000	0.000	0.000	0.000
roughtail skate	0.000	0.000	0.000	0.000
deepsea skate	0.000	0.000	0.000	0.000

Table 2. Incidental catches of skates in the Alaska Regional Office Catch Accounting System, 2011-2018. Data for 2018 are partial; retrieved August 21, 2018. Catches are categorized by total catch (all gear types) and by longline and trawl gears.

species code	species name	2011	2012	2013	2014	2015	2016	2017	2018
				total catch					
700	other skate	15,945	16,133	17,498	18,957	21,266	22,248	24,316	12,014
703	Alaska skate	6,941	7,357	8,386	7,049	5,593	5,417	6,067	3,843
705	whiteblotched skate	480	503	592	806	652	751	695	532
702	big skate	186	308	240	387	360	445	487	273
704	Aleutian skate	266	520	306	384	379	320	322	220
701	longnose skate	10	5	10	16	16	14	3	17
				longline only					
700	other skate	15,268	15,506	17,150	18,656	21,053	22,072	24,113	11,765
703	Alaska skate	2,001	2,563	3,043	3,336	3,228	3,183	3,051	1,365
702	big skate	97	269	208	288	278	305	306	158
705	whiteblotched skate	139	51	134	173	142	104	100	145
704	Aleutian skate	141	322	170	293	243	185	144	139
701	longnose skate	3	2	6	7	13	2	2	14
				trawl only					
703	Alaska skate	4,940	4,794	5,343	3,714	2,365	2,234	3,016	2,478
705	whiteblotched skate	341	453	457	633	510	648	595	388
700	other skate	676	627	347	301	213	176	203	249
702	big skate	88	40	32	99	82	140	181	115
704	Aleutian skate	125	198	136	92	136	135	179	81
701	longnose skate	7	2	5	9	3	12	1	3

Table 3. Species-specific catch estimates for BSAI skates, 2003-2017. "Skate unID" = unidentified skates which comprise the majority of the catch during 2003-2005.

	2003	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
Alaska	1,416	6,709	8,695	9,287	11,871	14,777	16,290	13,250	19,124	19,435	22,023	20,813	21,477	22,599	25,098
Bering	50	321	402	14	430	1,738	1,371	1,515	1,590	1,517	1,601	2,080	2,987	2,377	2,753
big	48	177	530	397	414	191	439	983	622	1,142	1,611	1,499	1,287	1,482	1,773
Aleutian	119	401	506	298	578	1,033	954	1,064	873	1,152	787	1,067	1,297	1,010	1,055
whiteblotched	20	277	121	60	170	1,454	340	427	1,132	581	694	1,214	831	914	861
skate unID	17,491	14,329	12,718	9,658	5,029	2,274	953	160	136	697	82	560	83	581	136
commander	3	14	47	4	93	87	134	104	174	108	120	203	109	107	82
mud	4	34	37	240	25	95	91	171	117	93	58	42	95	49	58
skate egg case	2	6	7	1	2	8	3	7	7	13	12	21	34	35	26
whitebrow	0.3	8.2	10.8	259.9	4.5	8.5	14.1	20.0	25.0	18.6	7.6	27.3	12.0	14.1	25.6
longnose	1.2	39.9	7.1	2.1	0.6	4.8	2.0	13.5	21.0	20.1	31.4	69.1	52.0	25.1	20.2
roughtail	0.2	13.7	2.9	17.9	3.5	6.6	4.2	15.4	5.6	4.0	3.6	3.8	2.2	2.1	3.7
deepsea	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	47.1	0.0	0.0	0.0	0.1	0.0
sandpaper	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Okhotsk	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
butterfly	0.0	0.0	0.0	9.6	1.7	0.0	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
total	19,154	22,329	23,084	20,250	18,623	21,677	20,596	17,730	23,827	24,827	27,031	27,599	28,266	29,196	31,891

Table 4. Species-specific catch estimates for BSAI skates, 2003-2017, with **the "skate unidentified" category apportioned to species with the new method**.

	2003	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
Alaska	16,698	17,541	19,061	16,937	15,936	16,351	17,021	13,357	19,230	19,981	22,089	21,241	21,540	23,063	25,205
Bering	659	1,301	1,094	16	675	2,021	1,476	1,536	1,602	1,574	1,607	2,132	2,996	2,430	2,765
big	443	644	1,277	983	651	215	468	995	626	1,185	1,617	1,532	1,290	1,512	1,781
Aleutian	1,065	1,150	1,080	731	869	1,171	1,014	1,077	879	1,189	790	1,092	1,301	1,030	1,060
whiteblotched	144	1,401	315	189	270	1,679	351	430	1,139	588	695	1,229	833	924	864
commander	77	69	140	14	167	101	145	105	176	112	121	208	110	110	82
mud	19	89	51	589	34	108	96	173	117	95	58	42	95	50	58
egg case	17	7	18	1	3	8	3	7	7	13	12	21	34	36	26
whitebrow	8	24	29	711	8	9	15	20	25	19	8	28	12	14	26
longnose	16	80	12	4	1	6	2	14	21	20	32	70	52	25	20
roughtail	5	21	7	56	6	8	5	16	6	4	4	4	2	2	4
deepsea	0	0	0	0	0	0	0	0	0	47	0	0	0	0	0
sandpaper	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Okhotsk	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
butterfly	0	0	0	18	3	0	0	0	0	0	0	0	0	0	0
total	19,154	22,329	23,084	20,250	18,623	21,677	20,596	17,730	23,827	24,827	27,031	27,599	28,266	29,196	31,891

Table 5. Species-specific catch estimates in **longline** fisheries for BSAI skates, 2003-2017.

	2003	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
Alaska	12,554	13,031	15,494	11,063	9,059	10,554	9,779	7,701	13,727	14,645	16,488	17,387	19,103	20,733	22,117
Bering	524	1,184	1,037	3	552	1,957	1,406	1,504	1,553	1,534	1,554	2,096	2,971	2,407	2,749
big	281	563	1,119	855	535	164	382	933	489	1,175	1,557	1,374	1,071	1,310	1,465
Aleutian	648	902	859	632	653	941	807	987	748	994	674	995	1,173	907	874
whiteblotched	69	1,359	290	188	227	1,549	154	214	824	164	254	601	366	302	334
commander	77	67	139	14	166	93	141	102	174	106	120	204	106	107	81
mud	4	67	20	509	20	89	68	142	89	54	24	18	78	27	34
egg case	13	1	17	1	2	1	3	7	2	11	8	19	31	32	24
whitebrow	8	20	28	660	7	5	13	19	25	16	6	26	11	14	24
longnose	13	48	7	3	0	5	2	5	15	11	23	28	42	9	10
roughtail	5	9	6	56	6	7	5	16	6	4	4	4	2	2	4
deepsea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
sandpaper	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Okhotsk	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
butterfly	0	0	0	11	3	0	0	0	0	0	0	0	0	0	0
total	14,197	17,251	19,016	13,995	11,231	15,366	12,760	11,629	17,651	18,713	20,711	22,752	24,955	25,851	27,716

Table 6. Species-specific catch estimates in **trawl** fisheries for BSAI skates, 2003-2017.

	2003	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
Alaska	4,144	4,510	3,567	5,875	6,877	5,798	7,242	5,656	5,504	5,336	5,602	3,854	2,437	2,330	3,089
whiteblotched	75	42	24	0	43	130	198	217	315	424	441	628	467	622	531
big	162	81	158	128	117	51	86	63	136	11	60	159	219	202	315
Aleutian	416	248	222	99	216	230	207	90	130	195	116	96	129	123	186
mud	15	22	31	80	14	18	28	31	29	41	34	24	17	22	25
Bering	135	117	57	14	123	64	69	32	49	40	53	35	25	23	16
longnose	3	32	5	1	0	0	0	9	6	10	9	42	10	16	10
commander	0	3	1	0	0	8	4	3	2	6	1	4	3	2	2
whitebrow	0	5	1	51	0	4	2	1	0	3	1	2	1	0	2
egg case	5	6	1	0	0	8	1	0	5	2	4	2	2	4	2
roughtail	0	12	1	0	0	0	0	0	0	0	0	0	0	0	0
deepsea	0	0	0	0	0	0	0	0	0	47	0	0	0	0	0
sandpaper	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Okhotsk	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
butterfly	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0
total	4,958	5,078	4,068	6,255	7,392	6,311	7,837	6,101	6,177	6,115	6,320	4,847	3,310	3,345	4,176

Table 7. Comparison of selected Alaska skate base model results using new versus old catch estimation methods.

	new catch	old catch
total likelihood	202.087	202.119
R_0	24,738	24,685
B_0	334,622	333,800
2016 B	251,012	250,165
2016 longline F	0.049	0.049
2016 trawl F	0.003	0.003

Figures

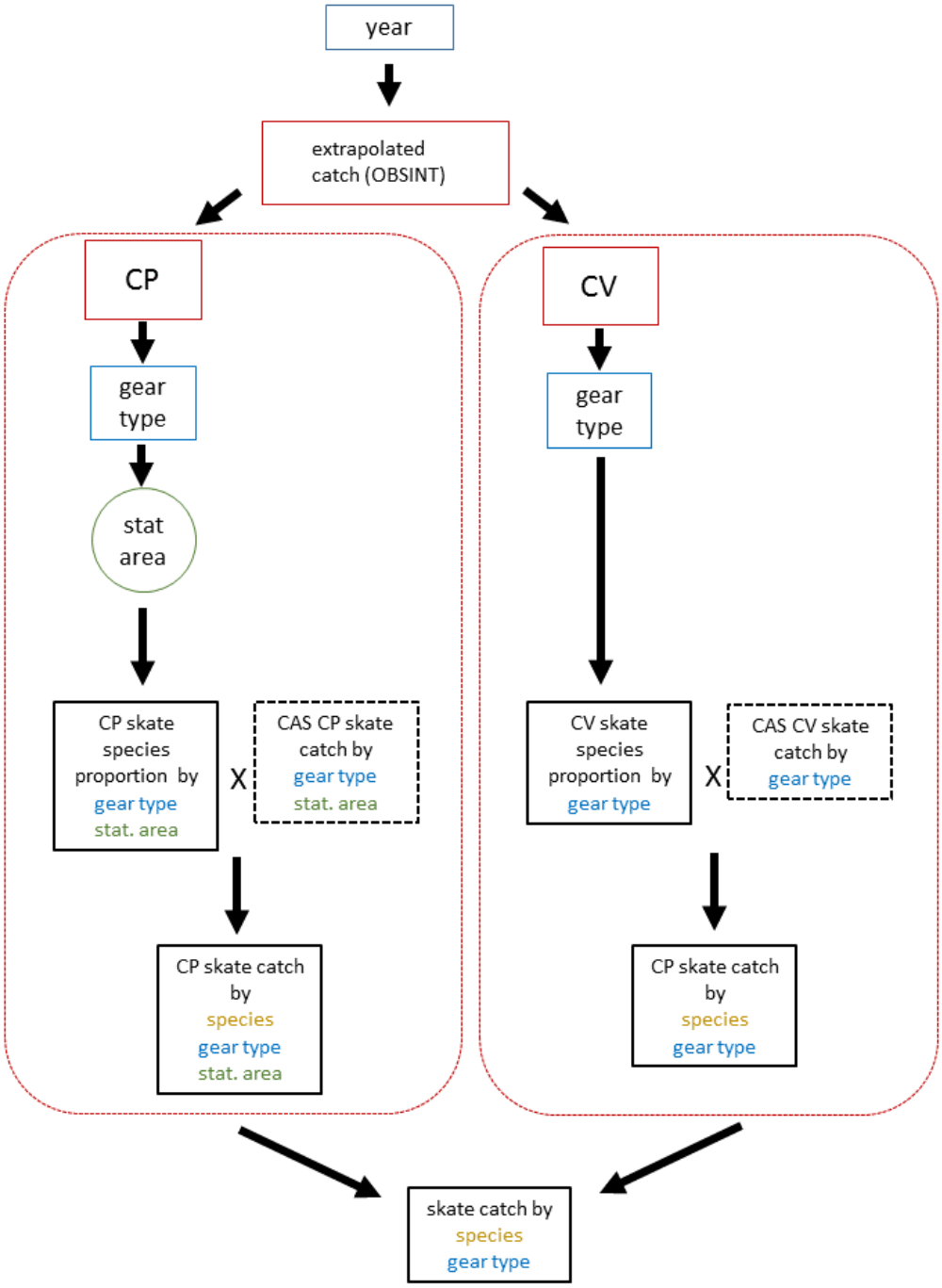

Figure 1. Graphical representation of the proposed skate catch estimation approach. CP = catcher-processor, CV = catcher vessel, CAS = Catch Accounting System, OTC = official total catch.

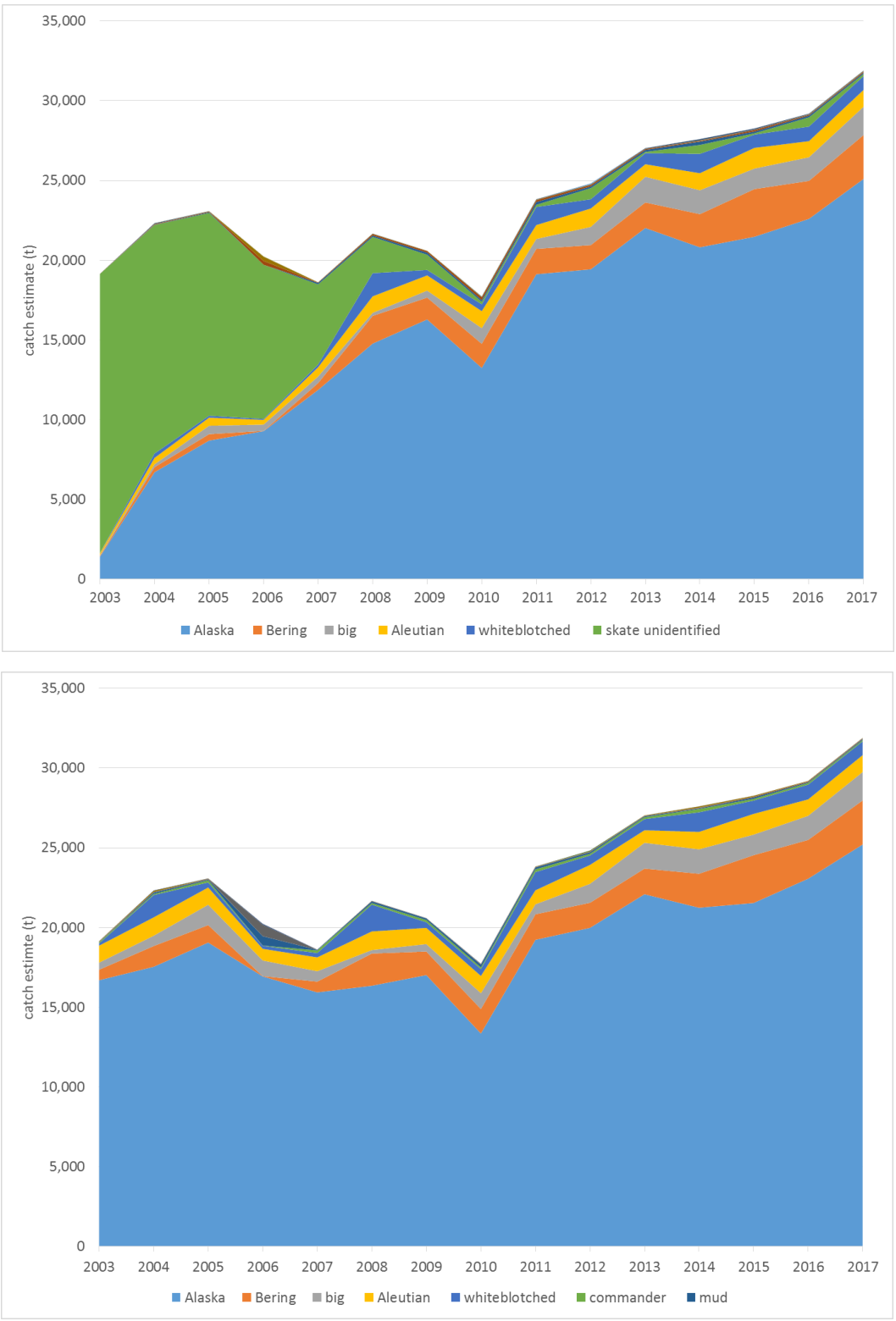

Figure 2. Estimated catches of skate species in the Bering Sea and Aleutian Islands, 2003-2017. Upper panel includes the "skate unidentified" category; lower panel displays data where the "skate unidentified" category has been apportioned to individual species.

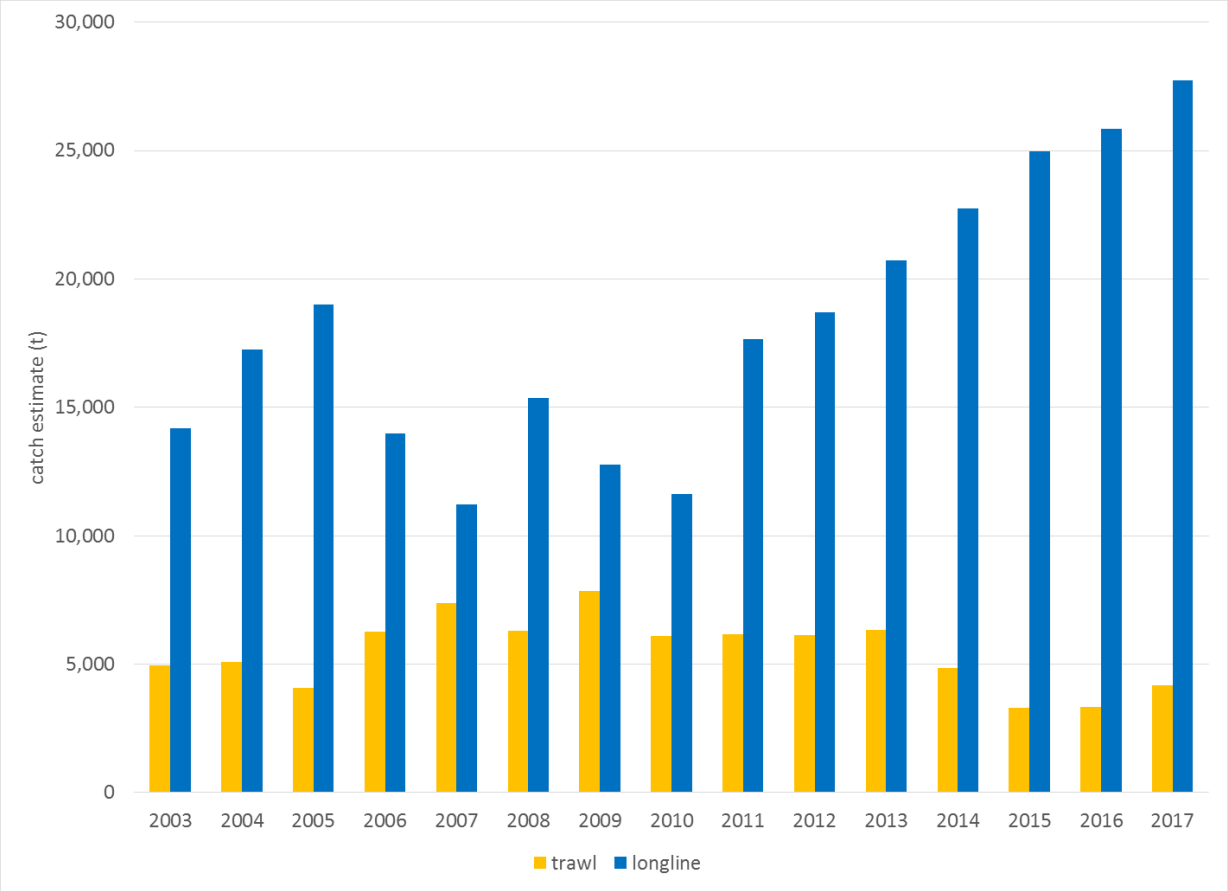

Figure 3. Estimated skate catches in the Bering Sea and Aleutian Islands **by gear type**, 2003-2017.

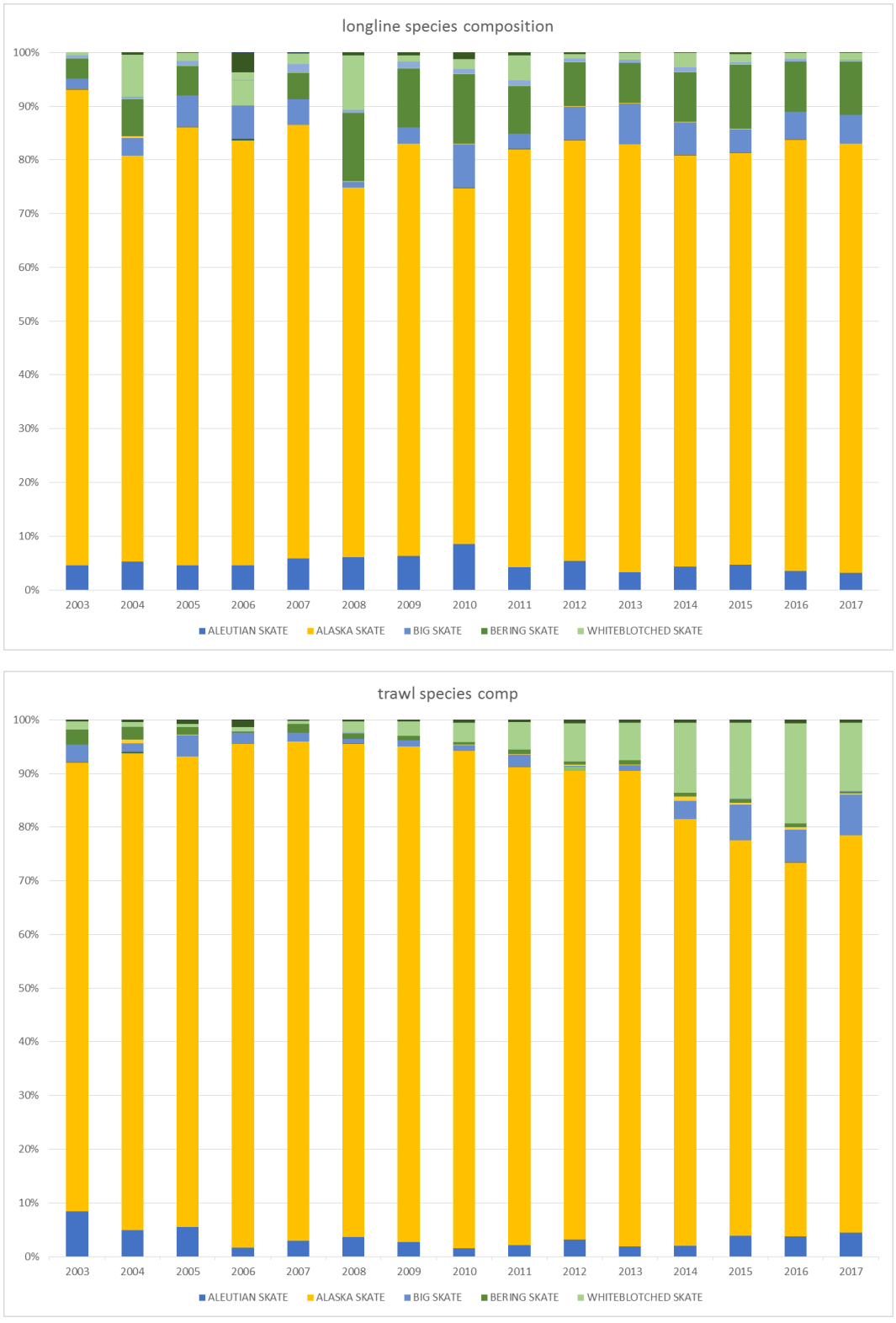

Figure 4. Species composition (% of total) of skate catches in longline fisheries (top panel) and trawl fisheries (bottom panel).

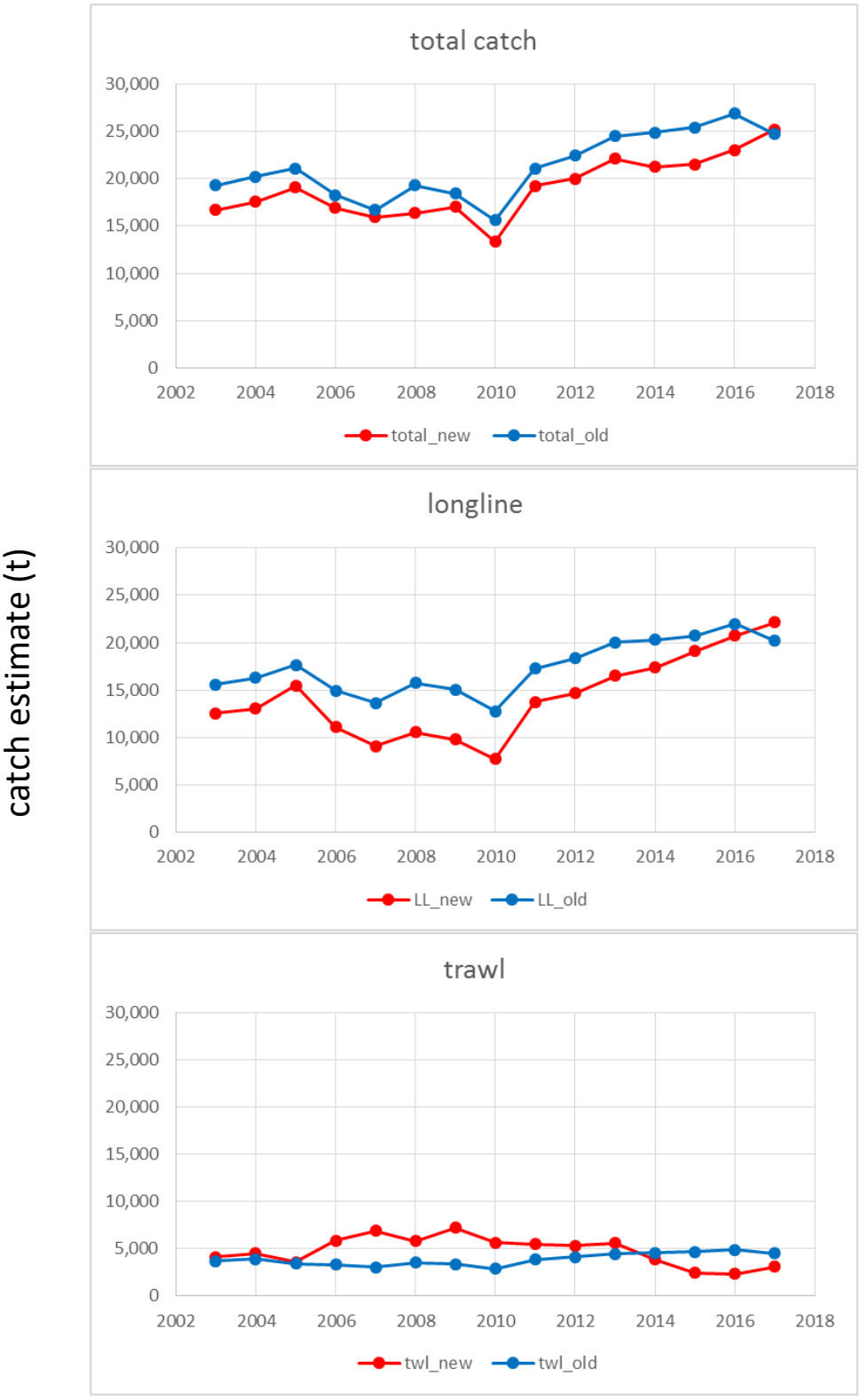

Figure 5. Comparison of catch estimates of Alaska skate, 2003-2017, between new (red) and old (blue) estimation methods. Data are shown as total catch (top), longline catch (middle), and trawl catch (bottom).