18. Assessment of the skate stock complex in the Gulf of Alaska

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Executive Summary

There are currently no target fisheries for skates in the Gulf of Alaska (GOA), and directed fishing for skates is prohibited. Incidental catches in other fisheries are sufficiently high that skates are considered to be "in the fishery" and harvest specifications are required. The GOA skate complex is managed as three units. Big skate (*Beringraja binoculata*) and longnose skate (*Raja rhina*) have separate harvest specifications, with gulfwide overfishing levels (OFLs) and Acceptable Biological Catches (ABCs) specified for each GOA regulatory area (western, central, and eastern). All remaining skate species are managed as an "other skates" group, with gulfwide harvest specifications. All GOA skates are managed under Tier 5, where OFL and ABC are based on survey biomass estimates and natural mortality rate.

Summary of Changes in Assessment Inputs

Changes in the input data:

1) Fully updated groundfish fishery catch data (2015 catch data as of October 18, 2015).
2) Biomass estimates and length composition data from the 2015 GOA bottom trawl survey.
3) Fishery length composition data through 2015.
4) An appendix containing information on catches of skates not accounted for in the Alaska Regional Office's Catch Accounting System, non-commercial catches, through 2015.

Changes in the assessment methodology:

1) A random effects (RE) model was introduced in the 2014 stock assessment and fishery evaluation (SAFE) report for use in estimating survey biomass. For the 2015 assessment, in response to Plan Team and SSC requests, a slight change was made in the methodology for applying the RE model. For each managed group (big, longnose, other) a separate RE model was run for each regulatory area. The harvest recommendations are based on these area-specific estimates, aggregated or not depending on the quantity. No gulfwide-RE models were run.

Summary of Results

1) The 2015 survey biomass for big skates increased substantially, mainly due to an increase in the estimate for the Central GOA regulatory area. This reversed a decline in CGOA big skate biomass that began in 2003. Big skate biomass declined slightly in the EGOA. The big skates in the EGOA tend to be younger and immature, so these results may indicate recruitment of a year class from the EGOA to the segment of the population in the CGOA.

2) The GOA-wide biomass estimate for longnose skate and "other skates" decreased slightly relative to 2013, but the biomass of both these groups has remained fairly stable since 2000. However the longnose skate biomass did shift somewhat among regulatory areas, with biomass increasing in the CGOA and declining in the WGOA and EGOA. The WGOA decline resulted in an ABC reduced to a level that the catch has exceeded in some previous years.

3) Application of the RE model to the survey data for big, longnose, and "other skates" continues to provide reasonable results.

4) Catches of all skate species groups are substantially lower than in the years preceding 2014 (particularly 2009-2013). This is likely due to prohibitions on retention of big skates in the CGOA that began in 2013, which discouraged "topping-off" behavior that resulted in high levels of catch, particularly for big skates in the CGOA.

The harvest recommendation summary table is on the following page. W, C, and E indicate the Western, Central, and Eastern GOA regulatory areas, respectively. Big and longnose skates have area-specific ABCs and gulfwide OFLs; "other skates" have a gulfwide ABC and OFL.

big skate (*Beringraja binoculata*)					
		As estimated or *specified last* year for		As estimated or *recommended this* year for:	
Quantity		*2015*	*2016*	**2016**	2017
M (natural mortality)		*0.1*	*0.1*	**0.1**	0.1
Specified/recommended Tier		*5*	*5*	**5**	5
Biomass (t)	W	*9,775*	*9,775*	**12,112**	12,112
	C	*16,810*	*16,810*	**24,666**	24,666
	E	*16,954*	*16,954*	**14,079**	14,079
	GOA-wide	*43,398*	*43,398*	**50,857**	50,857
F_{OFL} (F=M)		*0.1*	*0.1*	**0.1**	0.1
$maxF_{ABC}$		*0.075*	*0.075*	**0.075**	0.075
F_{ABC}		*0.075*	*0.075*	**0.075**	0.075
OFL (t)	GOA-wide	*4,340*	*4,340*	**5,086**	5,086
ABC (t; equal to maximum ABC)	W	*731*	*731*	**908**	908
	C	*1,257*	*1,257*	**1,850**	1,850
	E	*1,267*	*1,267*	**1,056**	1,056
Status		As determined *last* year for:		As determined *this* year for:	
		2013	2014	**2014**	2015
Overfishing?		*no*	*na*	**no**	na
(for Tier 5 stocks, data are not available to determine whether the stock is in an overfished condition)					

longnose skate (*Raja rhina*)					
		As estimated or *specified last* year for		As estimated or *recommended this* year for:	
Quantity		*2015*	*2016*	**2016**	2017
M (natural mortality)		*0.1*	*0.1*	**0.1**	0.1
Specified/recommended Tier		*5*	*5*	**5**	5
Biomass (t)	W	*2,009*	*2,009*	**808**	808
	C	*27,575*	*27,575*	**33,503**	33,503
	E	*12,873*	*12,873*	**8,426**	8,426
	GOA-wide	*42,911*	*42,911*	**42,737**	
F_{OFL} (*F=M*)		*0.1*	*0.1*	**0.1**	0.1
$maxF_{ABC}$		*0.075*	*0.075*	**0.075**	0.075
F_{ABC}		*0.075*	*0.075*	**0.075**	0.075
OFL (t)	GOA-wide	**4,291**	4,291	**4,274**	4,274
ABC (t; equal to maximum ABC)	W	**152**	152	**61**	61
	C	**2,090**	2,090	**2,513**	2,513
	E	**976**	976	**632**	632
		As determined *last* year for:		As determined *this* year for:	
Status		2013	2014	**2014**	2015
Overfishing?		*no*	*n/a*	**no**	n/a
(for Tier 5 stocks, data are not available to determine whether the stock is in an overfished condition)					

other skates (*Bathyraja* sp.)					
		As estimated or *specified last* year for		As estimated or *recommended this* year for:	
Quantity		*2015*	*2016*	**2016**	2017
M (natural mortality)		*0.1*	*0.1*	**0.1**	0.1
Specified/recommended Tier		*5*	*5*	**5**	5
Biomass (t)	GOA-wide	*29,797*	*29,797*	**25,580**	25,580
F_{OFL} (*F=M*)		*0.1*	*0.1*	**0.1**	0.1
$maxF_{ABC}$		*0.075*	*0.075*	**0.075**	0.075
F_{ABC}		*0.075*	*0.075*	**0.075**	0.075
OFL (t)	GOA-wide	*2,980*	*2,980*	**2,558**	2,558
ABC (t; equal to maximum ABC)	GOA-wide	*2,235*	*2,235*	**1,919**	1,919
		As determined last year for:		As determined *this* year for:	
Status		2013	2014	**2014**	2015
Overfishing?		*no*	*na*	**no**	na
(for Tier 5 stocks, data are not available to determine whether the stock is in an overfished condition)					

Responses to SSC and Plan Team Comments on Assessments in General

From the September 2015 Joint Plan Team minutes:
"The Teams recommend that the random effects survey smoothing model be used as a default for determining current survey biomass and apportionment among areas."

Response: This approach was adopted in the 2014 SAFE and will continue to be used in all future GOA skate assessments. The model is run separately for each species group (big, longnose, other) in each regulatory area.

Responses to SSC and Plan Team Comments Specific to this Assessment

From the December 2014 SSC minutes:
"The SSC requests clarification about whether the random effects model is used to determine subarea proportions or subarea totals for big and longnose skates. The summary tables in the SAFE starting on page 864 present subarea biomasses that supposedly do not add up to the reported Gulf-wide total, but the difference between the summation and reported values are negligible for both big skates and longnose skates. According to the footnotes, they do not add up, but they should for consistency. Second, it is unclear from the methods whether a random effects model is done or needed for other skates; the table above and the summary table in the SAFE only show a Gulf-wide total. The SSC suggests that scaling the subarea biomasses to the Gulf-wide total would be a simple solution."

Response: The approach used in the 2015 assessment (in response to the September 2015 Plan Team discussion and recommendation) is simplified relative to the 2014 assessment and directly addresses the issues raised by the SSC. Because there is a missing year of data for the EGOA, it is appropriate to conduct a separate RE model run for each area for each species group (big, longnose, other). The area-specific RE estimates were used to determine area ABCs for big and longnose skates. The area-specific estimates were aggregated to a GOA-wide total for determining big and longnose OFLs and "other skate" ABC and OFL. No gulf-wide RE models were run. As a result there are no longer any discrepancies in the totals. In addition, the reporting of results is now identical for the three skate species groups so that it is clear which set of models were completed.

"Provisionally the SSC accepts the subarea ABCs presented. An issue that needs attention in the next assessment is created by the many overages in subarea catches in reference to subarea ABCs, especially for big and longnose skates. The stock structure template suggests that skates are vulnerable in their subareas with respect to harvesting. The SSC believes that the subarea ABCs should be considered as real ABCs and not as apportionments. Thus the SSC is concerned about these overages in subarea ABCs."

Response: The author shares the SSC's belief and concerns. The approach used for the 2015 should be appropriate for determining "real ABCs".

Introduction

Description, scientific names, and general distribution

Skates (family Rajidae) are cartilaginous fishes related to sharks. At least 15 species of skates in four genera (*Raja*, *Beringraja*, *Bathyraja*, and *Amblyraja*) are found in Alaskan waters and are common from shallow inshore waters to very deep benthic habitats (Eschmeyer *et al* 1983; Stevenson *et al* 2007). In general, *Raja* species are most common and diverse in lower latitudes and shallower waters from the Gulf of Alaska to the Baja peninsula, while *Bathyraja* species are most common and diverse in the higher latitude habitats of the Bering Sea and Aleutian Islands, as well as in the deeper waters off the U.S. west coast. Table 1 lists the species found in Alaska, with their depth distributions and selected life history characteristics, which are outlined in more detail below.

In the Gulf of Alaska (GOA), the most common skate species are a *Raja* species, the longnose skate *R. rhina*; a *Beringraja* species, the big skate *B. binoculata*; and three *Bathyraja* species, the Aleutian skate *B. aleutica*, the Bering skate *B. interrupta*, and the Alaska skate *B. parmifera* (Tables 2 & 3, Figure 1). Big skates were previously in the genus *Raja*. The general range of the big skate extends from the Bering Sea to southern Baja California in depths ranging from 2 to 800 m. The longnose skate has a similar range, from the southeastern Bering Sea to Baja California in 9 to 1,069 m depths (Love *et al* 2005). While these two species have wide depth ranges, they are generally found in shallow waters in the GOA. One deep-dwelling *Amblyraja* species, the roughshoulder skate *A. badia*, ranges throughout the north Pacific from Japan to Central America at depths between 846 and 2,322 m; the four other species in the genus *Raja* are not found in Alaskan waters (Love *et al* 2005; Stevenson *et al* 2007). Within the genus *Bathyraja*, only two of the 13+ north Pacific species are not found in Alaska. Of the remaining 11+ species, only three are commonly found in the Gulf of Alaska. The Aleutian skate ranges throughout the north Pacific from northern Japan to northern California, and has been found in waters 16 to 1,602 m deep. The Alaska skate is restricted to higher latitudes from the Sea of Okhotsk to the eastern Gulf of Alaska in depths from 17-392 m (Stevenson *et al* 2007). The range of the Bering skate is difficult to determine at this time as it may actually be a complex of species, with each individual species occupying a different part of its general range from the western Bering Sea to southern California (Love *et al* 2005; Stevenson *et al* 2007).

The species within this assemblage occupy different habitats and regions within the GOA groundfish Fishery Management Plan (FMP). In this assessment, we distinguish habitat primarily by depth for GOA skates. The highest biomass of skates is found in the shallowest continental shelf waters of less than 100 m depth, and is dominated by the big skate (Figure 2). In continental shelf waters from 100-200 m depth, longnose skates dominate skate biomass, and *Bathyraja* skate species are dominant in the deeper waters extending from 200 to 1000 m or more in depth (Figure 2). These depth distributions are reflected in the spatial distribution of GOA skates. Big skates are located inshore and are most abundant in the central and western GOA (Figures 3 & 4). Longnose skates (Figures 4 & 5) are located further offshore and appear to be more widespread than big skates

Life history and stock structure (skates in general)

Skate life cycles are similar to sharks, with relatively low fecundity, slow growth to large body sizes, and dependence of population stability on high survival rates of a few well developed offspring (Moyle and Cech 1996). Sharks and skates in general have been classified as “equilibrium” life history strategists, with very low intrinsic rates of population increase implying that sustainable harvest is possible only at very low to moderate fishing mortality rates (King and McFarlane 2003). Within this general equilibrium life history strategy, there can still be considerable variability between skate species in terms of life history parameters (Walker and Hislop 1998). While smaller-sized species have been observed to be somewhat more productive, large skate species with late maturation (11+ years) are most vulnerable to heavy fishing pressure (Walker and Hislop 1998; Frisk *et al* 2001; Frisk *et al* 2002). The most extreme cases of overexploitation have been reported in the North Atlantic, where the now ironically named common skate *Dipturus batis* has been extirpated from the Irish Sea (Brander 1981) and much of the North Sea (Walker and Hislop 1998). The mixture of life history traits between smaller and larger skate species has led to apparent population stability for the aggregated “skate” group in many areas where fisheries occur. This has masked the decline of individual skate species in European fisheries (Dulvy *et al* 2000). Similarly, in the Atlantic off New England, declines in barndoor skate *Dipturus laevis* abundance were concurrent with an increase in the biomass of skates as a group (Sosebee 1998).

Several recent studies have explored the effects of fishing on a variety of skate species to determine which life history traits and stages are the most important for management. While full age-structured modeling is difficult for many of these data-poor species, Leslie matrix models parameterized with information on fecundity, age/size at maturity, and longevity have been applied to identify the life stages most important to population stability. Major life stages include the egg stage, the juvenile stage, and the

adult stage (summarized here based on Frisk *et al* 2002). All skate species are oviparous (egg-laying), investing considerably more energy per large, well-protected embryo than commercially exploited groundfish. The large, leathery egg cases incubate for extended periods (months to a year) in benthic habitats, exposed to some level of predation and physical damage, until the fully formed juveniles hatch. The juvenile stage lasts from hatching through maturity, several years to over a decade depending on the species. The reproductive adult stage may last several more years to decades depending on the species.

Age and size at maturity and adult size/longevity appear to be more important predictors of resilience to fishing pressure than fecundity or egg survival in the skate populations studied to date. Frisk *et al* (2002) estimated that although annual fecundity per female may be on the order of less than 50 eggs per year (extremely low compared with teleost groundfish), there is relatively high survival of eggs due to the high parental investment (without disturbance from fishing operations). Therefore, egg survival did not appear to be the most important life history stage contributing to population stability under fishing pressure. Juvenile survival appears to be most important to population stability for most North Sea species studied (Walker and Hilsop 1998), and for the small and intermediate sized skates from New England (Frisk *et al* 2002). For the large and long-lived barndoor skates, adult survival was the most important contributor to population stability (Frisk *et al* 2002). In all cases, skate species with the largest adult body sizes (and the empirically related large size/age at maturity, Frisk *et al* 2001) were least resilient to high fishing mortality rates. This is most often attributed to the long juvenile stage during which relatively large yet immature skates are exposed to fishing mortality, and also explains the mechanism for the shift in species composition to smaller skate species in heavily fished areas. Comparisons of length frequencies for surveyed North Sea skates from the mid- and late-1900s led Walker and Hilsop (1998, p. 399) to the conclusion that "all the breeding females, and a large majority of the juveniles, of *Dipturus batis*, *R. fullonica* and *R. clavata* have disappeared, whilst the other species have lost only the very largest individuals." Although juvenile and adult survival may have different importance by skate species, all studies found that one metric, adult size, reflected overall sensitivity to fishing. After modeling several New England skate populations, Frisk *et al* (2002, p. 582) found "a significant negative, nonlinear association between species total allowable mortality, and species maximum size."

There are clear implications of these results for sustainable management of skates in Alaska. After an extensive review of population information for many elasmobranch species, Frisk et al (2001, p. 980) recommended that precautionary management be implemented especially for the conservation of large species:

> "(*i*) size based fishery limits should be implemented for species with either a large size at maturation or late maturation, (*ii*) large species (>100 cm) should be monitored with increased interest and conservative fishing limits implemented, (*iii*) adult stocks should be maintained, as has been recommended for other equilibrium strategists (Winemiller and Rose 1992)."

Life history and stock structure (Alaska-specific)

Information on fecundity in North Pacific skate species is extremely limited. There are one to seven embryos per egg case in North Pacific Ocean *Raja* species (Eschmeyer *et al* 1983), but little is known about frequency of breeding or egg deposition for any of the local species. Similarly, information related to breeding or spawning habitat, egg survival, hatching success, or other early life history characteristics is extremely sparse for GOA skates (although current research is addressing these issues for Alaska skates in the Eastern Bering sea; J. Hoff, AFSC, pers. comm.; see also the 2009 BSAI skate SAFE, Ormseth and Matta 2009).

Slightly more is known about juvenile and adult life stages for GOA skates. In terms of maximum adult size, the *Raja* species are larger than the *Bathyraja* species found in the area. The big skate, *Raja binoculata*, is the largest skate in the Gulf of Alaska, with maximum sizes observed over 200 cm in the directed fishery in 2003 (see the "Fishery" and "Survey" sections below, for details). Observed sizes for

the longnose skate, *Raja rhina*, are somewhat smaller at about 165-170 cm. Therefore, the Gulf of Alaska *Raja* species are in the same size range as the large Atlantic species, i.e., the common skate *Dipturus batis* and the barndoor skate, which historically had estimated maximum sizes of 237 cm and 180 cm, respectively (Walker and Hislop 1998, Frisk *et al* 2002). The maximum observed lengths for *Bathyraja* species from bottom trawl surveys of the GOA range from 86-154 cm.

Known life history parameters of Alaskan skate species are presented in Table 1. Zeiner and Wolf (1993) determined age at maturity and maximum age for big and longnose skates from Monterey Bay, CA. The maximum age of CA big skates was 11-12 years, with maturity occurring at 8-11 years; estimates of maximum age for CA longnose skates were 12-13 years, with maturity occurring at 6-9 years. McFarlane and King (2006) completed a study of age, growth, and maturation of big and longnose skates in the waters off British Columbia (BC), finding maximum ages of 26 years for both species, much older than the estimates of Zeiner and Wolf. Age at 50% maturity occurs at 6-8 years in BC big skates, and at 7-10 years in BC longnose skates. However, these parameter values may not apply to Alaskan stocks. The AFSC Age and Growth Program has recently reported a maximum observed age of 25 years for the longnose skate in the GOA, significantly higher than that found by Zeiner and Wolf but close to that observed by McFarlane and King (Gburski *et al* 2007). In the same study, the maximum observed age for GOA big skates was 15 years, closer to Zeiner and Wolf's results for California big skates.

Fishery

Directed fishery, bycatch, and discards in federal waters

Prior to 2005 directed fishing was allowed for GOA skates and appears to have occurred in some years (Table 4). The occurrence of these fisheries was driven by the ex-vessel prices for skates; sufficiently high prices made it worthwhile to specifically target skates. This directed fishing was especially problematic because skates were managed as part of the "Other Species" assemblage and harvest limits were not directly based on skate abundance. In response to these events skates were separated from "Other Species" and in 2005 directed fishing for skates was prohibited (and remains so).

Interest in retention of skates and directed fishing for skates remains high. The ABC for big skates in the CGOA was exceeded every year during 2010-2013, and the ABC for longnose skates in the WGOA was exceeded in 4 of the years 2007-2013 (Table 5 and Figure 6). Incidental catches of big and longnose skates occur in a variety of target fisheries; the greatest catches presently occur in the arrowtooth flounder, Pacific cod, and Pacific halibut fisheries (Table 6). Reported retention rates of big and longnose skates were high during the late 2000s (Table 7). Big skate retention has declined since 2012 as a result of limits on retention of big skates in the CGOA that have been imposed because of the ABC overages. In 2013, retention of big skate was prohibited in the CGOA for the rest of the year on May 8; in 2014 & 2015 that same action was taken in February almost immediately after target fisheries opened. These actions reduced retention of big skate, but the retention of longnose skates continues to be high.

Alaska state-waters fishery 2009-2010

Prior to 2006, directed fishing for skates in state waters was allowed by Commissioner's Permit; in 2006 skates were placed on bycatch status only. In 2008, the Alaska state legislature appropriated funds for developing the data collection (e.g. onboard observers) necessary to open a state-waters directed fishery. In 2009 and 2010, the state conducted a limited skate fishery in the eastern portions of the Prince William Sound (PWS) Inside and Outside Districts. In 2009, the guideline harvest level (GHL) was based on skate exploitation rates in federal groundfish fisheries and NMFS survey estimates of skate biomass. This was changed for 2010, when GHLs were based on ADF&G trawl survey results. The GHLs and harvests for 2009 and 2010 were as follows (in lbs.; harvests exceeding the GHL are indicated in **bold**):

Year	2009		2010	
Skate Species	big	longnose	big	longnose
Inside District GHL (lbs)	20,000	100,000	20,000	110,000
Inside District Harvest (lbs)	**47,220**	68,828	**20,382**	68,681
Outside District GHL (lbs)	30,000	150,000	30,000	155,000
Outside District Harvest (lbs)	**82,793**	59,538	6,190	9,257

* Thanks to Charlie Trowbridge of ADF&G for state-waters skate harvest data.

The big skate GHL was exceeded by a substantial amount in 2009. In 2010, trip catch limits for big skates were imposed to reduce the potential for exceeding the GHL. The improved management resulted in a much smaller overage in the PWS Inside District and no overage in the PWS Outside District. The state-waters skate fishery was discontinued in 2011 after the legislature failed to approve continued funds for data collection.

Management units

Since the beginning of domestic fishing in the late 1980s up through 2003, all species of skates in the GOA were managed under the "Other Species" FMP category (skates, sharks, squids, sculpins, and octopuses). Catch within this category was historically limited by a Total Allowable Catch (TAC) for all "Other Species" calculated as 5% of the sum of the TACs for GOA target species. The "Other Species" category was established to monitor and protect species groups that were not currently economically important in North Pacific groundfish fisheries, but which were perceived to be ecologically important and of potential economic importance as well. The configuration of the "Other Species" group was relatively stable until 2004, when GOA skates were removed from the category for separate management in response to a developing fishery. In 2004 the skate species that were the targets of the 2003 fishery (big and longnose skates) were managed together under a single TAC in the central GOA (CGOA), where the fishery had been concentrated in 2003. The remaining skates were managed as an "other skates" species complex in the CGOA, and all skates including big and longnose skates were managed as an "other skates" species complex in the western GOA (WGOA) and eastern GOA (EGOA). Since 2005, to address concerns about disproportionate harvest of skates, big skate and longnose skate have had separate ABCs and TACs for the WGOA, CGOA, and EGOA. The remaining skates ("other skates") continue to be managed as a gulfwide species complex because they are not generally retained and are difficult to distinguish at the species level.

Data

Fishery

Catch data: Catches were recorded using the Blend system from 1992-2002 (Table 4). Since 2003 skate catch data are recorded in the Alaska Regional Office Catch Accounting System (CAS; Tables 4 & 5). Additional details are available in the sections above.

Fishery length compositions: Fishery observers have been required to collect length data for skates in selected fisheries since 2009, and fishery length compositions have been constructed for the years 2009-2015 for big skate (Figure 7) and longnose skate (Figure 8). The 100-103 cm size bin in these figures is colored fuchsia to aid in the interpretation of changes in the size compositions; there is no significance to that particular bin. These data suggest that fisheries are capturing a narrower size range of longnose skate

relative to big skate, and that captured longnose skates are slightly larger on average. Length compositions do not vary substantially among trawl and longline fisheries (Figure 9); this may be because much of the length data comes from retained skates, and skates are generally retained only if they are above a minimum size.

Survey

Bottom trawl survey biomass estimates: There are several potential indices of skate abundance in the Gulf of Alaska, including longline and trawl surveys. For this assessment, the NMFS summer bottom trawl surveys 1984-2015 is the primary source of information on the biomass and distribution of the major skate species (Tables 2, 3 & 8; Figures 10-12). On a gulf-wide basis, big and longnose skate biomass estimates have been fairly stable since the late 1990s (Table 2 & Figure 10). Area-specific biomass has shown greater fluctuations (Table 8 & Figure 11). Until the 2015 trawl survey, biomass estimates in the CGOA had declined substantially, but the 2015 CGOA estimate increased dramatically. "Other skate" biomass declined slightly from the 2013 estimate (Table 2 & Figure 12).

Random effects model biomass estimates: To produce biomass estimates suitable for harvest specifications, biomass was also estimated using a random effects (RE) model developed by the Joint Plan Team Survey Averaging Working Group. For each group (big, longnose, other), a separate RE model was run for each regulatory area (Tables 9a-9c; Figures 13-15). The RE model produced reasonable results. RE model estimates generally varied more than the running average, but reduced the influence of anomalous survey estimates and large CVs. As a result, the RE model estimates were used for developing harvest recommendations.

Survey length compositions: Length data are collected for skates during the GOA bottom trawl surveys. The survey length composition of big skates is diffuse, with few clear size modes (Figure 16; as described above, the fuchsia-colored size bin is marked for reference only). Since 2003, the composition has been fairly stable, with the majority of individuals clustered between approximately 76 and 148 cm. An apparent abundance of large big skates in 2001 may be due to the lack of survey effort in the Eastern GOA, where smaller skates are more common (see below). The 2009, 2011, and particularly 2013 surveys captured more small skates than in previous years, which may indicate an increase in recruitment or a decrease in the number of larger skates. In contrast to big skates, the data for longnose skates display a consistent size mode at approximately 120 cm (Figure 17). Since 2011 this distribution seems to have shifted slightly, with an increase in smaller sizes and the possible emergence of two length modes.

The length distribution of big skates differs among GOA regulatory areas (Figure 18). The largest big skates tend to be found in the WGOA and the smallest big skates in the Eastern GOA. Intermediate sizes dominate in the CGOA, where a size mode is more distinct than in the other areas. The length composition of longnose skates varies much less among the areas (Figure 19), although data for longnose in the WGOA are sparse. These patterns may reflect differences in migratory behavior. The pattern for big skates is similar to patterns observed in the Alaska skate population in the Bering Sea, where there appears to be an ontogenetic migration offshore as skates mature (Hoff 2007). A similar process may exist for GOA big skates.

Analytic Approach

Skates in the GOA are managed using Tier 5. Under Tier 5, $F_{OFL} = M$ and OFL = F_{OFL} * average survey biomass. Maximum permissible ABC is calculated as 0.75 * F_{OFL} * average survey biomass.

Area-specific random effects (RE) models were used to make harvest recommendations. The F_{ABC} for each species group was applied to the area estimates to produce an ABC for each area. For "other skates" the area ABCs were aggregated to produce a Gulfwide ABC. For OFL specification in all groups, the area –specific estimates were aggregated and the F_{OFL} was applied to the total.

Parameter estimates

Natural mortality (*M)*

A value of M = 0.1 has been used for GOA skate harvest recommendations since 2003. During the CIE review of non-target stock assessments in 2013, several reviewers felt that the use of 0.1 was overly conservative and did not include the best available data. The author agrees that the value of *M* has not been revisited in the light of recent Alaska-specific data and recent analyses of the *F=M* methodology, and this is planned for a future assessment.

Results

Harvest recommendations

big skate (*Beringraja binoculata*)					
		As estimated or *specified last* year for		As estimated or *recommended this* year for:	
Quantity		*2015*	*2016*	**2016**	2017
M (natural mortality)		*0.1*	*0.1*	**0.1**	0.1
Specified/recommended Tier		*5*	*5*	**5**	5
Biomass (t)	W	*9,775*	*9,775*	**12,112**	12,112
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	E	*16,954*	*16,954*	**14,079**	14,079
	GOA-wide	*43,398*	*43,398*	**50,857**	50,857
F_{OFL} (*F=M*)		*0.1*	*0.1*	**0.1**	0.1
$maxF_{ABC}$		*0.075*	*0.075*	**0.075**	0.075
F_{ABC}		*0.075*	*0.075*	**0.075**	0.075
OFL (t)	GOA-wide	*4,340*	*4,340*	**5,086**	5,086
ABC (t; equal to maximum ABC)	W	*731*	*731*	**908**	908
	C	*1,257*	*1,257*	**1,850**	1,850
	E	*1,267*	*1,267*	**1,056**	1,056
Status		As determined *last* year for:		As determined *this* year for:	
		2013	2014	**2014**	2015
Overfishing?		*no*	*na*	**no**	na
(for Tier 5 stocks, data are not available to determine whether the stock is in an overfished condition)					

longnose skate (*Raja rhina*)					
		As estimated or *specified last* year for		As estimated or *recommended this* year for:	
Quantity		*2015*	*2016*	**2016**	2017
M (natural mortality)		*0.1*	*0.1*	**0.1**	0.1
Specified/recommended Tier		*5*	*5*	**5**	5
Biomass (t)	W	*2,009*	*2,009*	**808**	808
	C	*27,575*	*27,575*	**33,503**	33,503
	E	*12,873*	*12,873*	**8,426**	8,426
	GOA-wide	*42,911*	*42,911*	**42,737**	
F_{OFL} (*F=M*)		*0.1*	*0.1*	**0.1**	0.1
$maxF_{ABC}$		*0.075*	*0.075*	**0.075**	0.075
F_{ABC}		*0.075*	*0.075*	**0.075**	0.075
OFL (t)	GOA-wide	**4,291**	4,291	**4,274**	4,274
ABC (t; equal to maximum ABC)	W	**152**	152	**61**	61
	C	**2,090**	2,090	**2,513**	2,513
	E	**976**	976	**632**	632
		As determined *last* year for:		As determined *this* year for:	
Status		2013	2014	**2014**	2015
Overfishing?		*no*	*n/a*	**no**	n/a
(for Tier 5 stocks, data are not available to determine whether the stock is in an overfished condition)					

other skates (*Bathyraja* sp.)					
		As estimated or *specified last* year for		As estimated or *recommended this* year for:	
Quantity		*2015*	*2016*	**2016**	2017
M (natural mortality)		*0.1*	*0.1*	**0.1**	0.1
Specified/recommended Tier		*5*	*5*	**5**	5
Biomass (t)	GOA-wide	*29,797*	*29,797*	**25,580**	25,580
F_{OFL} (*F=M*)		*0.1*	*0.1*	**0.1**	0.1
$maxF_{ABC}$		*0.075*	*0.075*	**0.075**	0.075
F_{ABC}		*0.075*	*0.075*	**0.075**	0.075
OFL (t)	GOA-wide	*2,980*	*2,980*	**2,558**	2,558
ABC (t; equal to maximum ABC)	GOA-wide	*2,235*	*2,235*	**1,919**	1,919
		As determined last year for:		As determined *this* year for:	
Status		2013	2014	**2014**	2015
Overfishing?		*no*	*na*	**no**	na
(for Tier 5 stocks, data are not available to determine whether the stock is in an overfished condition)					

Ecosystem Considerations

In the following tables, we summarize ecosystem considerations for GOA skates and the entire groundfish fishery where they are caught incidentally. The observation column represents the best attempt to summarize the past, present, and foreseeable future trends. The interpretation column provides details on how ecosystem trends might affect the stock (ecosystem effects on the stock) or how the fishery trend affects the ecosystem (fishery effects on the ecosystem). The evaluation column indicates whether the trend is of: *no concern, probably no concern, possible concern, definite concern,* or *unknown.*

Ecosystem effects on GOA Skates *(evaluating level of concern for skate populations)*

Indicator	Observation	Interpretation	Evaluation
Prey availability or abundance trends			
Non-pandalid shrimp, other benthic organisms	Trends are not currently measured directly, only short time series of food habits data exist for potential retrospective measurement	Unknown	Unknown
Sandlance, capelin, other forage fish	Trends are not currently measured directly, only short time series of food habits data exist for potential retrospective measurement	Unknown	Unknown
Commercial flatfish	Increasing to steady populations currently at high biomass levels	Adequate forage available for piscivorous skates	No concern
Pollock	High population level in early 1980s declined to stable low level at present	Currently a small component of skate diets, skate populations increased over same period	No concern
Predator population trends			
Steller sea lions	Declined from 1960s, low but level recently	Lower mortality on skates?	No concern
Sharks	Population trends unknown	Unknown	Unknown
Sperm whales	Populations recovering from whaling?	Possibly higher mortality on skates? But still a very small proportion of mortality	No concern
Changes in habitat quality			
Benthic ranging from shallow shelf to deep slope, isolated nursery areas in specific locations	Skate habitat is only beginning to be described in detail. Adults appear adaptable and mobile in response to habitat changes. Eggs are limited to isolated nursery grounds and juveniles use different habitats than adults. Changes in these habitats have not been monitored historically, so assessments of habitat quality and its trends are not currently available.	Continue study on small nursery areas to evaluate importance to population production, initiate study for GOA big and longnose skates	Possible concern if nursery grounds are disturbed or degraded.

Groundfish fishery effects on ecosystem via skate bycatch *(evaluating level of concern for ecosystem)*

Indicator	Observation	Interpretation	Evaluation
Fishery contribution to bycatch			
Skate catch	Varies from 6,000 to 10,000 + tons annually including halibut fishery	Largest portion of total mortality for skates	Possible concern
Forage availability	Skates have few predators, and skates are small proportion of diets for their predators	Fishery removal of skates has a small effect on predators	Probably no concern
Fishery concentration in space and time	Skate bycatch is spread throughout FMP areas, but directed skate catch was concentrated in isolated areas in 2003	Potential impact to skate populations if fishery disturbs nursery or other important habitat; but small effect on skate predators	Possible concern for skates, probably no concern for skate predators
Fishery effects on amount of large size target fish	2005 survey sampling suggests possible decrease in largest big skates	Larger big skates more rare due to fishing or other factors?	Possible concern
Fishery contribution to discards and offal production	Skate discard a moderate proportion of skate catch, many incidentally caught skates are retained and processed	Unclear whether discard of skates has ecosystem effect	Unknown
Fishery effects on age-at-maturity and fecundity	Skate age at maturity and fecundity are still being described; fishery effects on them difficult to determine	Unknown	Unknown

Data gaps and research priorities

Because fishing mortality appears to be a larger proportion of skate mortality in the GOA than predation mortality, highest priority research should continue to focus on direct fishing effects on skate populations. The most important component of this research is to fully evaluate the catch and discards in all fisheries capturing skates. It is also vital to continue research on the productive capacity of skate populations, including information on age and growth, maturity, fecundity, and habitat associations.

Although predation appears less important than fishing mortality on adult skates, juvenile skates and skate egg cases are likely much more vulnerable to predation. This effect has not been evaluated in population or ecosystem models. We expect to learn more about the effects of predation on skates, especially as juveniles, with the completion of Jerry Hoff's (AFSC, RACE) research on skate nursery areas in the Bering Sea.

Skate habitat is only beginning to be described in detail. Adults appear capable of significant mobility in response to general habitat changes. However, eggs are limited to isolated nursery grounds and juveniles use different habitats than adults. Disturbance to these habitats could have disproportionate population effects. Changes in these habitats have not been monitored historically, so assessments of habitat quality and its trends are not currently available. We recommend continued study on skate nursery areas to evaluate importance to population production.

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Tables

Table 1. Life history and depth distribution information available for BSAI and GOA skate species, from Stevenson (2004) unless otherwise noted.

Species	Common name	Max obs. length (TL cm)	Max obs. age	Age, length Mature (50%)	Feeding mode [2]	N embryos/ egg case [1]	Depth range (m) [9]
Bathyraja abyssicola	deepsea skate	135 (M) [10] 157 (F) [11]	?	110 cm (M) [11] 145 cm (F) [13]	benthophagic; predatory [11]	1 [13]	362-2904
Bathyraja aleutica	Aleutian skate	150 (M) 154 (F) [12]	14 [6]	121 cm (M) 133 cm (F) [12]	predatory	1	15-1602
Bathyraja interrupta	Bering skate (complex?)	83 (M) 82 (F) [12]	19 [6]	67 cm (M) 70 cm (F) [12]	benthophagic	1	26-1050
Bathyraja lindbergi	Commander skate	97 (M) 97 (F) [12]	?	78 cm (M) 85 cm (F) [12]	?	1	126-1193
Bathyraja maculata	whiteblotched skate	120	?	94 cm (M) 99 cm (F) [12]	predatory	1	73-1193
Bathyraja mariposa [3]	butterfly skate	76	?	?	?	1	90-448
Bathyraja minispinosa	whitebrow skate	83[10]	?	70 cm (M) 66 cm (F) [12]	benthophagic	1	150-1420
Bathyraja parmifera	Alaska skate	118 (M) 119 (F) [4]	15 (M) 17 (F) [4]	9 yrs, 92cm (M) 10 yrs, 93cm(F) [4]	predatory	1	17-392
Bathyraja sp. cf parmifera	"Leopard" parmifera	133 (M) 139 (F)	?	?	predatory	?	48-396
Bathyraja taranetzi	mud skate	67 (M) 77 (F) [12]	?	56 cm (M) 63 cm (F) [12]	predatory [13]	1	58-1054
Bathyraja trachura	roughtail skate	91 (M) [14] 89 (F) [11]	20 (M) 17 (F) [14]	13 yrs, 76 cm (M) 14 yrs, 74 cm (F)[14, 12]	benthophagic; predatory [11]	1	213-2550
Bathyraja violacea	Okhotsk skate	73	?	?	benthophagic	1	124-510
Amblyraja badia	roughshoulder skate	95 (M) 99 (F) [11]	?	93 cm (M) [11]	predatory [11]	1 [13]	1061-2322
Raja binoculata	big skate	244	15 [5]	4.8 yrs, 68 cm (F) 6.1 yrs, 87 cm (M) [6]	predatory [8]	1-7	16-402
Raja rhina	longnose skate	180	25 [5]	12.3 yrs, 96 cm (F) 8.8 yrs, 72 cm (M) [6]	benthophagic; predatory [15]	1	9-1069

[1] Eschemeyer 1983. [2] Orlov 1998 & 1999 (Benthophagic eats mainly amphipods, worms. Predatory diet primarily fish, cephalopods). [3] Stevenson et al. 2004. [4] Matta 2006. [5] Gburski et al. 2007. [6] Gburski unpub data. [7] McFarlane & King 2006. [8] Wakefield 1984. [9] Stevenson et al. 2006. [10] Mecklenberg et al. 2002. [11] Ebert 2003. [12] Ebert 2005. [13] Ebert unpub data. [14] Davis 2006. [15] Robinson 2006.

Table 2. Gulfwide bottom trawl survey biomass estimates (t) for the three managed skate groups in the GOA, 1984-2015. CV = coefficient of variation.

	big skate		**longnose skate**		**other skate**		**total skate**
	biomass (t)	CV	biomass (t)	CV	biomass (t)	CV	**biomass**
1984	27,540	0.22	9,002	0.38	4,647	0.16	41,189
1987	28,093	0.16	6,631	0.36	3,339	0.21	38,063
1990	22,316	0.25	11,995	0.22	13,936	0.25	48,248
1993	39,708	0.18	17,803	0.12	6,191	0.14	63,702
1996	43,064	0.18	26,226	0.14	11,912	0.17	81,201
1999	54,650	0.15	39,333	0.14	18,946	0.11	112,929
2001	39,082	0.19	23,275	0.16	12,857	0.16	75,214
2003	55,397	0.16	39,603	0.09	21,775	0.11	116,775
2005	39,320	0.16	41,370	0.08	29,998	0.11	110,688
2007	39,630	0.19	34,470	0.11	32,289	0.11	106,388
2009	44,349	0.16	36,652	0.09	27,399	0.12	108,401
2011	67,883	0.37	33,911	0.11	21,389	0.10	123,183
2013	38,234	0.26	44,484	0.11	30,705	0.11	113,423
2015	58,006	0.17	41,833	0.09	25,182	0.11	125,020

Table 3. Bottom trawl survey biomass estimates (t) for skates in each GOA regulatory area, 1984-2015.

		1984	1987	1990	1993	1996	1999	2001	2003	2005	2007	2009	2011	2013	2015
	big	3,339	4,313	1,745	2,287	13,130	11,038	8,425	9,602	9,792	5,872	6,652	6,251	10,669	13,449
	longnose	0	41	1,045	105	278	1,747	104	782	1,719	628	1,214	941	2,127	708
	Bering	45	20	28	0	52	218	170	39	86	0	283	237	37	142
	mud	0	0	0	0	0	46	0	0	0	0	10	7	0	43
	roughtail	0	0	0	0	43	0	0	0	0	82	0	0	0	0
WGOA	Alaska	0	0	0	0	119	220	1,213	265	211	177	1,728	333	1,124	802
	Aleutian	358	112	139	292	82	1,928	1,858	4,401	1,453	3,333	3,051	873	2,970	2,514
	whiteblotched	0	0	0	0	0	544	0	173	502	197	199	487	0	359
	whitebrow	0	0	0	0	0	0	0	0	0	33	0	0	0	0
	misc skates	325	351	0	664	466	1	3	1	36	0	838	28	0	37
	total WGOA	**4,067**	**4,837**	**2,956**	**3,348**	**14,168**	**15,741**	**11,774**	**15,264**	**13,797**	**10,322**	**13,975**	**9,157**	**16,926**	**18,053**
	big	17,635	20,855	9,071	21,586	26,544	34,007	30,658	33,814	25,544	24,420	26,691	21,761	12,810	31,996
	longnose	2,280	2,667	8,708	14,158	20,328	29,872	23,171	25,741	29,853	26,083	25,534	23,609	28,274	34,149
	Bering	230	519	1,861	107	1,492	3,371	2,423	3,526	3,910	3,480	3,370	3,429	3,501	2,788
	mud	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	roughtail	51	182	0	0	0	614	0	0	139	495	356	0	0	326
CGOA	Alaska	0	14	771	0	810	1,272	2,422	1,579	489	1,620	1,021	708	2,907	943
	Aleutian	1,235	601	896	60	5,681	8,055	4,734	10,772	22,395	21,928	15,725	13,409	17,972	15,950
	whiteblotched	0	0	0	0	0	925	0	0	0	0	0	0	0	0
	whitebrow	8	0	0	0	0	0	0	0	0	84	0	0	72	0
	misc skates	2,108	1,273	9,618	3,602	1,692	32	33	33	0	16	51	21	0	0
	total CGOA	**23,548**	**26,112**	**30,924**	**39,513**	**56,546**	**78,148**	**63,440**	**75,465**	**82,331**	**78,125**	**72,748**	**62,937**	**65,537**	**86,153**
	big	6,566	2,925	11,501	15,836	3,391	9,606		11,981	3,984	9,337	11,007	39,870	14,755	12,560
	longnose	6,722	3,923	2,242	3,539	5,620	7,714		13,081	9,797	7,759	9,904	9,362	14,083	6,975
	Bering	187	68	159	119	673	229		136	342	335	473	191	426	180
	mud	0	0	0	0	0	0		0	0	0	0	0	0	0
	roughtail	0	0	0	0	0	63		0	0	371	0	0	0	442
EGOA	Alaska	4	0	107	0	0	76		63	0	0	0	0	0	0
	Aleutian	0	25	216	0	796	1,310		640	406	138	295	1,663	1,697	657
	whiteblotched	0	0	0	0	0	0		91	0	0	0	0	0	0
	whitebrow	0	0	0	0	0	0		52	0	0	0	0	0	0
	misc skates	96	173	143	1,347	8	42		3	31	0	0	2	0	1
	total EGOA	**13,575**	**7,114**	**14,367**	**20,841**	**10,487**	**19,040**		**26,046**	**14,559**	**17,941**	**21,678**	**51,089**	**30,960**	**20,814**
GOA-wide		**41,189**	**38,063**	**48,248**	**63,702**	**81,201**	**112,929**	**75,214**	**116,775**	**110,688**	**106,388**	**108,401**	**123,183**	**113,423**	**125,020**

Table 4. Total allowable catch (TAC) and catch for GOA "Other Species" and skates, with estimated skate catch, 1992-2004. Before 2004, skate were managed as part of the Other Species group; in 2004 skates were managed separately. Management changed again in 2005 and "modern era" results are included in Table 6.

	TAC			Other Species catch	est. skate catch			management method
	W	**C**	**E**		**W**	**C**	**E**	
1992		13,432		12,313		1,835		Other species TAC
1993		14,602		6,867		3,882		Other species TAC
1994		14,505		2,721		1,770		Other species TAC
1995		13,308		3,421		1,273		Other species TAC
1996		12,390		4,480		1,868		Other species TAC
1997		13,470		5,439		3,120		Other species TAC
1998		15,570		3,748		4,476		Other species TAC
1999		14,600		3,858		2,000		Other species TAC
2000		14,215		5,649		3,238		Other species TAC
2001		13,619		4,801		1,828		Other species TAC
2002		11,330		3,748		6,484		Other species TAC
2003		11,260		6,262		4,527		Other species TAC
2004		3,284		5,865		1,569		Big/Longnose CGOA
		3,709				1,451		other skates gulfwide + big/longnose W/E

Sources: TAC and Other species catch from AKRO catch statistics website. Estimated skate catch 1992-1996 from Gaichas et al 1999. Estimated skate catch 1997-2002 from Gaichas et al 2003 (see Table 7 in this assessment). Estimated skate catch 2003-2004 from AKRO Catch Accounting System (CAS).

Table 5. Harvest specifications and catch (t) for skates in the GOA, beginning in 2005 when the current management regime for GOA skates was initiated. ABC and catch are divided by GOA regulatory area (**W**estern, **C**entral, **E**astern) for big and longnose skates; for "other skates", the ABC column indicates the gulfwide ABC. The additional EGOA field (E_2) includes catches in EGOA inside waters (areas 649 & 659); for "other skates". Red-shaded cells with bold text indicate years/areas where the catch exceeded the ABC. * 2014 are incomplete; retrieved October 8, 2014.

	species/ group	**ABC**				**OFL**	**estimated skate catch**				
		W	**C**	**E**	**GOA**		**W**	**C**	**E**	**(E_2)**	**GOA**
2005	big	727	2,463	809		5,332	26	811	65	(67)	
	longnose	66	1,972	780		3,757	37	993	162	(173)	
	other				1,327	1,769	163	506	42	(50)	711
2006	big	695	2,250	599		4,726	72	1,272	344	(388)	
	longnose	65	1,969	861		3,860	57	682	219	(296)	
	other				1,617	2,156	354	988	51	(72)	1,393
2007	big	695	2,250	599		4,726	69	1,518	8	(11)	
	longnose	65	1,969	861		3,860	76	978	342	(388)	
	other				1,617	2,156	479	690	88	(107)	1,257
2008	big	632	2,065	633		4,439	132	1,241	45	(49)	
	longnose	78	2,041	768		3,849	34	965	113	(130)	
	other				2,104	2,806	252	1,053	69	(103)	1,374
2009	big	632	2,065	633		4,439	79	1,903	100	(137)	
	longnose	78	2,041	768		3,849	**79**	1,096	244	(319)	
	other				2,104	2,806	343	1,092	113	(160)	1,548
2010	big	598	2,049	681		4,438	148	2,220	149	(179)	
	longnose	81	2,009	762		3,803	105	846	131	(197)	
	other				2,093	2,791	421	986	83	(118)	1,491
2011	big	598	2,049	681		4,438	110	2,111	90	(134)	
	longnose	81	2,009	762		3,803	71	892	68	(118)	
	other				2,093	2,791	313	977	59	(96)	1,349
2012	big	469	1,793	1,505		5,023	66	1,902	38	(62)	
	longnose	70	1,879	676		3,500	39	793	93	(134)	
	other				2,030	2,706	256	843	104	(140)	1,202
2013	big	469	1,793	1,505		5,023	121	2,320	79	(221)	
	longnose	70	1,879	676		3,500	90	1,255	429	(848)	
	other				2,030	2,706	218	1,487	174	(371)	1,879
2014	big	589	1,532	1,641		5,016	157	1,411	103	(233)	
	longnose	107	1,935	834		3,835	59	1,159	355	(576)	
	other				1,989	2,652	305	1,369	240	(496)	1,914
2015*	big	589	1,532	1,641		5,016	163	1,097	58	(128)	
	longnose	107	1,935	834		3,835	65	917	309	(523)	
	other				1,989	2,652	204	819	150	(293)	1,173

Table 6a. Catches of **big skate** (t) by target fishery, 2005-2015. Data are from the Alaska Regional Office Catch Accounting System. * 2015 are incomplete; retrieved October 18, 2015.

big skate											
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	*2015**
Pacific cod	222	417	539	586	559	948	961	755	650	939	*711*
IFQ halibut	37	608	11	34	171	42	145	39	523	442	*379*
arrowtooth	225	163	299	219	433	484	817	677	949	190	*194*
pollock	2	23	38	22	34	47	93	48	228	171	*57*
shallow flatfish	251	350	608	413	535	700	190	288	140	26	*24*
sablefish	24	10	6	6	7	13	2	4	9	4	*10*
rockfish	19	4	0	4	4	14	8	13	2	4	*6*
rex sole	49	99	74	70	264	172	106	149	145	25	*6*
flathead sole	21	30	23	66	53	112	31	57	15	0	*2*
misc	56	27	0	2	60	14	1	0	1	0	*0*
deep flatfish	0	0	0	0	0	1	1	0	0	0	*0*
total	904	1,732	1,598	1,421	2,119	2,547	2,356	2,031	2,663	1,801	*1,389*

Table 6b. Catches of **longnose skate** (t) by target fishery, 2005-2015. Data are from the Alaska Regional Office Catch Accounting System. * 2015 are incomplete; retrieved October 18, 2015.

longnose skate											
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	*2015**
IFQ halibut	106	210	424	109	444	112	196	122	1,006	553	*570*
Pacific cod	139	165	307	361	352	430	375	327	436	470	*541*
arrowtooth	373	135	165	212	152	166	238	181	218	303	*149*
sablefish	113	351	297	137	88	116	74	134	351	192	*132*
pollock	5	13	27	24	35	10	35	9	25	180	*46*
rockfish	20	21	17	12	17	12	25	23	23	26	*31*
shallow flatfish	278	97	168	227	239	172	78	65	70	36	*18*
flathead sole	11	11	13	11	24	30	17	60	8	11	*10*
rex sole	19	29	24	36	82	52	44	45	54	23	*8*
misc	137	2	0	0	61	47	0	0	1	0	*0*
Atka mackerel	0	0	0	0	0	0	0	0	1	0	*0*
deep flatfish	1	0	0	0	0	1	0	0	0	0	*0*
total	1,202	1,034	1,441	1,129	1,495	1,148	1,082	966	2,193	1,794	*1,505*

Table 6c. Catches of "**other skates"** by target fishery (t), 2005-2015. Data are from the Alaska Regional Office Catch Accounting System. * 2015 are incomplete; retrieved October 18, 2015.

	other skates										
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	*2015**
Pacific cod	175	981	531	958	908	1,077	800	704	910	1,075	*645*
IFQ halibut	47	81	116	36	275	39	147	107	740	610	*345*
sablefish	129	136	270	162	96	147	125	158	235	209	*180*
arrowtooth	194	64	123	88	99	133	242	174	63	163	*89*
rockfish	59	49	20	10	13	27	15	20	18	45	*21*
pollock	1	5	9	6	3	7	2	6	24	17	*12*
shallow flatfish	36	27	79	107	98	35	20	33	44	28	*10*
flathead sole	38	12	20	5	13	19	13	17	8	1	*8*
rex sole	36	56	103	22	60	41	21	20	33	21	*5*
misc	2	3	5	16	30	0	0	0	0	0	*0*
Atka mackerel	0	0	0	0	0	0	2	0	0	0	*0*
deep flatfish	0	0	0	0	0	0	0	0	0	1	*0*
total	719	1,414	1,277	1,409	1,595	1,525	1,386	1,239	2,075	2,170	*1,315*

Table 7. Retention rates of skates in GOA fisheries, 2007-2015. Data are from tables published by the Alaska Regional Office. Retention rates in 2013-2015 were influenced by management actions; see footnotes.

	other skates	**big skate**	**longnose skate**
2007	27%	46%	28%
2008	17%	70%	64%
2009	18%	76%	51%
2010	15%	72%	64%
2011	19%	81%	65%
2012	13%	93%	74%
2013[1]	1%	63%	36%
2014[2]	5%	26%	51%
2015[3]*	*4%*	*17%*	*50%*

[1] On May 8, 2013 retention of big skate was prohibited in the CGOA.
[2] On February 5, 2014 retention of big skate was prohibited in the CGOA.
[3] On February 11, 2015 retention of big skate was prohibited in the CGOA.

* 2015 data are incomplete; retrieved October 30, 2015

Table 8a. Bottom trawl survey biomass estimates (t) for big skates by regulatory area, 1984-2015. CV = coefficient of variation.

	big skate					
	WGOA		CGOA		EGOA	
	biomass	CV	biomass	CV	biomass	CV
1984	3,339	0.22	17,635	0.23	6,566	0.60
1987	4,313	0.16	20,855	0.19	2,925	0.47
1990	1,745	0.25	9,071	0.35	11,501	0.39
1993	2,287	0.18	21,586	0.19	15,836	0.37
1996	13,130	0.18	26,544	0.19	3,391	0.30
1999	11,038	0.15	34,007	0.20	9,606	0.34
2001	8,425	0.19	30,658	0.22	n/a	-
2003	9,602	0.16	33,814	0.22	11,981	0.38
2005	9,792	0.16	25,544	0.21	3,984	0.36
2007	5,872	0.19	23,249	0.26	9,337	0.33
2009	6,652	0.16	26,691	0.22	11,007	0.32
2011	6,251	0.37	21,761	0.17	39,870	0.61
2013	10,669	0.26	12,810	0.21	14,755	0.56
2015	13,449	0.24	31,996	0.19	12,560	0.53

Table 8b. Bottom trawl survey biomass estimates (t) for longnose skates by regulatory area, 1984-2015. CV = coefficient of variation.

	longnose skate					
	WGOA		CGOA		EGOA	
	biomass	CV	biomass	CV	biomass	CV
1984	n/a	n/a	2,280	0.77	6,722	0.44
1987	41	0.83	2,667	0.30	3,923	0.57
1990	1,045	0.71	8,708	0.29	2,242	0.26
1993	105	0.72	14,158	0.15	3,539	0.19
1996	278	0.64	20,328	0.17	5,620	0.18
1999	1,747	0.52	29,872	0.18	7,714	0.17
2001	104	0.71	23,171	0.16	n/a	n/a
2003	782	0.45	25,741	0.12	13,081	0.15
2005	1,719	0.36	29,853	0.09	9,876	0.18
2007	628	0.47	26,034	0.12	7,759	0.24
2009	1,214	0.64	25,534	0.10	9,904	0.19
2011	941	0.43	23,609	0.14	9,362	0.19
2013	2,127	0.33	28,274	0.14	14,083	0.17
2015	708	0.41	34,149	0.10	6,975	0.22

Table 9a. Biomass estimates (t) and coefficients of variation (CV) for **big skates** in 3 regions of the GOA. Estimates are annual trawl survey estimates (surv est) or estimates from a random effects model fit to each survey timeseries (RE est).

	WGOA				CGOA				EGOA			
	surv est	**surv CV**	**RE est**	**RE CV**	**surv est**	**surv CV**	**RE est**	**RE CV**	**surv est**	**surv CV**	**RE est**	**RE CV**
1984	3,339	0.56	3,574	0.37	17,635	0.23	18,459	0.17	6,566	0.56	5,642	0.44
1985			3,622	0.35			18,684	0.17			5,286	0.47
1986			3,671	0.31			18,912	0.16			4,953	0.45
1987	4,313	0.29	3,720	0.24	20,855	0.19	19,142	0.14	2,925	0.45	4,641	0.39
1988			3,394	0.29			18,747	0.17			5,889	0.41
1989			3,096	0.32			18,360	0.19			7,472	0.39
1990	1,745	0.45	2,824	0.32	9,071	0.34	17,981	0.21	11,501	0.38	9,482	0.32
1991			2,985	0.34			19,099	0.19			10,051	0.40
1992			3,154	0.33			20,286	0.17			10,655	0.41
1993	2,287	0.32	3,334	0.28	21,586	0.18	21,548	0.14	15,836	0.36	11,294	0.33
1994			4,407	0.29			22,871	0.15			8,399	0.38
1995			5,825	0.30			24,275	0.15			6,246	0.37
1996	13,130	0.40	7,699	0.29	26,544	0.19	25,765	0.13	3,391	0.29	4,645	0.29
1997			8,323	0.31			27,045	0.15			5,654	0.37
1998			8,999	0.29			28,388	0.16			6,882	0.37
1999	11,038	0.26	9,729	0.22	34,007	0.20	29,798	0.15	9,606	0.33	8,376	0.28
2000			9,412	0.25			29,846	0.15			8,588	0.40
2001	8,425	0.34	9,105	0.23	30,658	0.21	29,893	0.14			8,805	0.43
2002			9,165	0.25			29,715	0.15			9,028	0.40
2003	9,602	0.28	9,226	0.21	33,814	0.21	29,539	0.14	11,981	0.37	9,256	0.30
2004			9,002	0.25			28,198	0.14			7,373	0.34
2005	9,792	0.32	8,785	0.22	25,544	0.21	26,917	0.13	3,984	0.35	5,873	0.31
2006			8,032	0.26			26,137	0.14			7,216	0.34
2007	5,872	0.42	7,343	0.26	24,420	0.26	25,379	0.14	9,337	0.33	8,865	0.26
2008			7,241	0.27			24,833	0.14			10,203	0.33
2009	6,652	0.36	7,140	0.24	26,691	0.21	24,298	0.13	11,007	0.31	11,743	0.25
2010			7,283	0.26			23,109	0.13			14,795	0.37
2011	6,251	0.30	7,429	0.23	21,761	0.17	21,979	0.12	39,870	0.57	18,641	0.41
2012			8,529	0.26			21,000	0.15			17,114	0.41
2013	10,669	0.40	9,793	0.24	12,810	0.20	20,064	0.17	14,755	0.52	15,712	0.36
2014			10,891	0.26			22,247	0.15			14,873	0.42
2015	13,449	0.24	12,112	0.22	31,996	0.19	24,666	0.16	12,560	0.53	14,079	0.41

Table 9b. Biomass estimates (t) and coefficients of variation (CV) for **longnose skates** in 3 regions of the GOA. Estimates are annual trawl survey estimates (surv est) or estimates from a random effects model fitted to each survey timeseries (RE est).

	WGOA				CGOA				EGOA			
	surv est	**surv CV**	**RE est**	**RE CV**	**surv est**	**surv CV**	**RE est**	**RE CV**	**surv est**	**surv CV**	**RE est**	**RE CV**
1984					2,280	0.68	3,489	0.40	6,722	0.42	4,761	0.33
1985							3,633	0.37			4,400	0.33
1986							3,783	0.33			4,066	0.31
1987	41	0.72	75	0.69	2,667	0.30	3,939	0.27	3,923	0.53	3,758	0.28
1988			140	0.78			4,977	0.27			3,451	0.28
1989			262	0.76			6,287	0.25			3,169	0.26
1990	1,045	0.64	490	0.62	8,708	0.28	7,943	0.20	2,242	0.25	2,911	0.22
1991			340	0.75			9,541	0.23			3,154	0.24
1992			236	0.74			11,460	0.21			3,417	0.22
1993	105	0.64	164	0.57	14,158	0.15	13,764	0.13	3,539	0.19	3,703	0.16
1994			204	0.75			15,590	0.20			4,230	0.21
1995			253	0.73			17,659	0.20			4,833	0.21
1996	278	0.59	314	0.51	20,328	0.17	20,002	0.14	5,620	0.18	5,521	0.15
1997			472	0.71			22,088	0.21			6,166	0.20
1998			709	0.71			24,390	0.21			6,886	0.20
1999	1,747	0.49	1,065	0.48	29,872	0.17	26,933	0.15	7,714	0.17	7,691	0.15
2000			527	0.64			25,586	0.18			8,553	0.21
2001	104	0.64	261	0.60	23,171	0.16	24,307	0.13			9,513	0.23
2002			438	0.64			25,114	0.17			10,580	0.21
2003	782	0.43	737	0.38	25,741	0.12	25,949	0.10	13,081	0.15	11,766	0.14
2004			1,042	0.58			27,527	0.16			10,839	0.18
2005	1,719	0.35	1,473	0.33	29,853	0.09	29,202	0.09	9,797	0.18	9,986	0.14
2006			1,055	0.58			27,756	0.16			9,423	0.19
2007	628	0.44	756	0.40	26,083	0.12	26,381	0.11	7,759	0.24	8,892	0.17
2008			901	0.62			25,949	0.17			9,275	0.19
2009	1,214	0.58	1,075	0.47	25,534	0.10	25,524	0.09	9,904	0.18	9,674	0.15
2010			1,057	0.61			25,063	0.17			9,809	0.18
2011	941	0.41	1,038	0.37	23,609	0.14	24,611	0.12	9,362	0.19	9,945	0.15
2012			1,391	0.58			26,442	0.17			10,823	0.18
2013	2,127	0.32	1,864	0.30	28,274	0.14	28,409	0.12	14,083	0.17	11,779	0.15
2014			1,227	0.58			30,851	0.17			9,963	0.19
2015	708	0.41	808	0.39	34,149	0.10	33,503	0.10	6,975	0.22	8,426	0.19

Table 9c. Biomass estimates (t) and coefficients of variation (CV) for **other skates** in 3 regions of the GOA. Estimates are annual trawl survey estimates (surv est) or estimates from a random effects model fitted to each survey timeseries (RE est).

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	WGOA				CGOA				EGOA			
	surv est	**surv CV**	**RE est**	**RE CV**	**surv est**	**surv CV**	**RE est**	**RE CV**	**surv est**	**surv CV**	**RE est**	**RE CV**
1984	728	0.27	684	0.25	3,632	0.20	3,593	0.19	287	0.25	311	0.24
1985			606	0.37			3,498	0.30			335	0.30
1986			537	0.37			3,406	0.31			362	0.31
1987	483	0.29	476	0.25	2,590	0.26	3,316	0.23	266	0.49	390	0.30
1988			410	0.38			4,620	0.31			462	0.31
1989			354	0.42			6,438	0.31			548	0.28
1990	167	0.43	305	0.38	13,146	0.26	8,970	0.25	624	0.27	649	0.22
1991			420	0.41			7,121	0.31			795	0.27
1992			579	0.39			5,653	0.29			974	0.27
1993	956	0.32	797	0.27	3,769	0.19	4,487	0.18	1,467	0.29	1,193	0.23
1994			847	0.38			5,712	0.29			1,261	0.28
1995			900	0.38			7,271	0.29			1,333	0.27
1996	761	0.34	956	0.29	9,675	0.20	9,255	0.18	1,476	0.26	1,410	0.21
1997			1,342	0.38			10,521	0.28			1,432	0.27
1998			1,885	0.36			11,961	0.28			1,453	0.28
1999	2,956	0.26	2,647	0.23	14,269	0.14	13,597	0.13	1,721	0.30	1,475	0.24
2000			2,963	0.33			12,019	0.24			1,354	0.29
2001	3,245	0.35	3,317	0.27	9,612	0.17	10,623	0.16			1,243	0.31
2002			3,811	0.32			13,050	0.24			1,142	0.30
2003	4,880	0.21	4,377	0.20	15,910	0.14	16,030	0.13	985	0.37	1,048	0.26
2004			3,572	0.32			20,433	0.24			988	0.28
2005	2,286	0.32	2,915	0.26	26,934	0.12	26,045	0.11	779	0.46	931	0.27
2006			3,342	0.33			26,537	0.24			924	0.27
2007	3,823	0.28	3,832	0.23	27,622	0.12	27,037	0.11	844	0.32	917	0.23
2008			4,411	0.32			23,708	0.24			955	0.26
2009	6,109	0.23	5,079	0.21	20,523	0.14	20,789	0.13	767	0.34	994	0.24
2010			3,616	0.31			19,372	0.24			1,188	0.26
2011	1,965	0.27	2,574	0.24	17,567	0.11	18,051	0.11	1,857	0.35	1,419	0.25
2012			3,115	0.32			20,633	0.24			1,491	0.28
2013	4,130	0.27	3,769	0.23	24,453	0.13	23,584	0.12	2,122	0.44	1,567	0.28
2014			3,826	0.31			21,863	0.24			1,497	0.30
2015	3,896	0.18	3,883	0.17	20,007	0.13	20,267	0.12	1,279	0.38	1,430	0.30

Figures

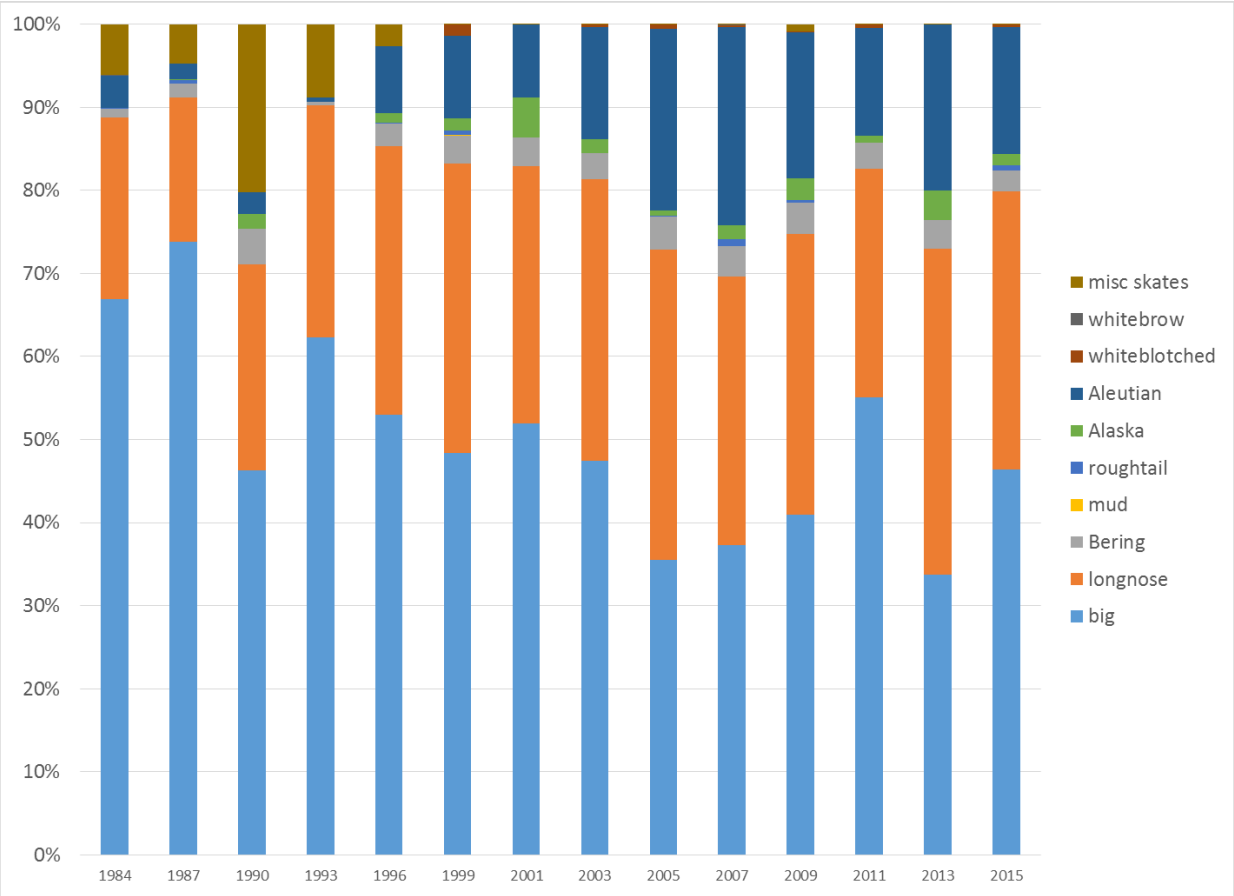

Figure 1. Gulfwide species composition of GOA skates, 1996-2015. The 2001 survey did not sample in the EGOA.

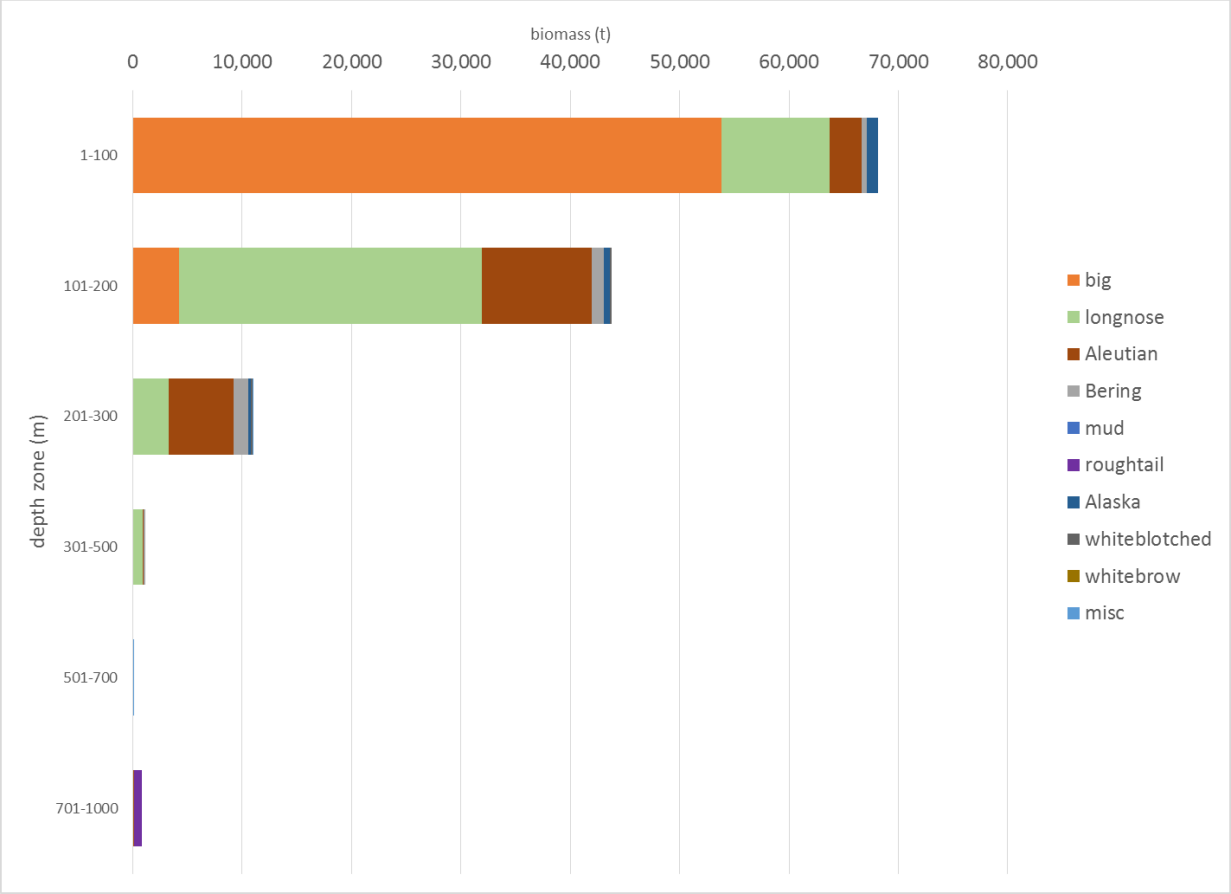

Figure 2. 2015 survey biomass estimates (t) at depth for GOA skate species.

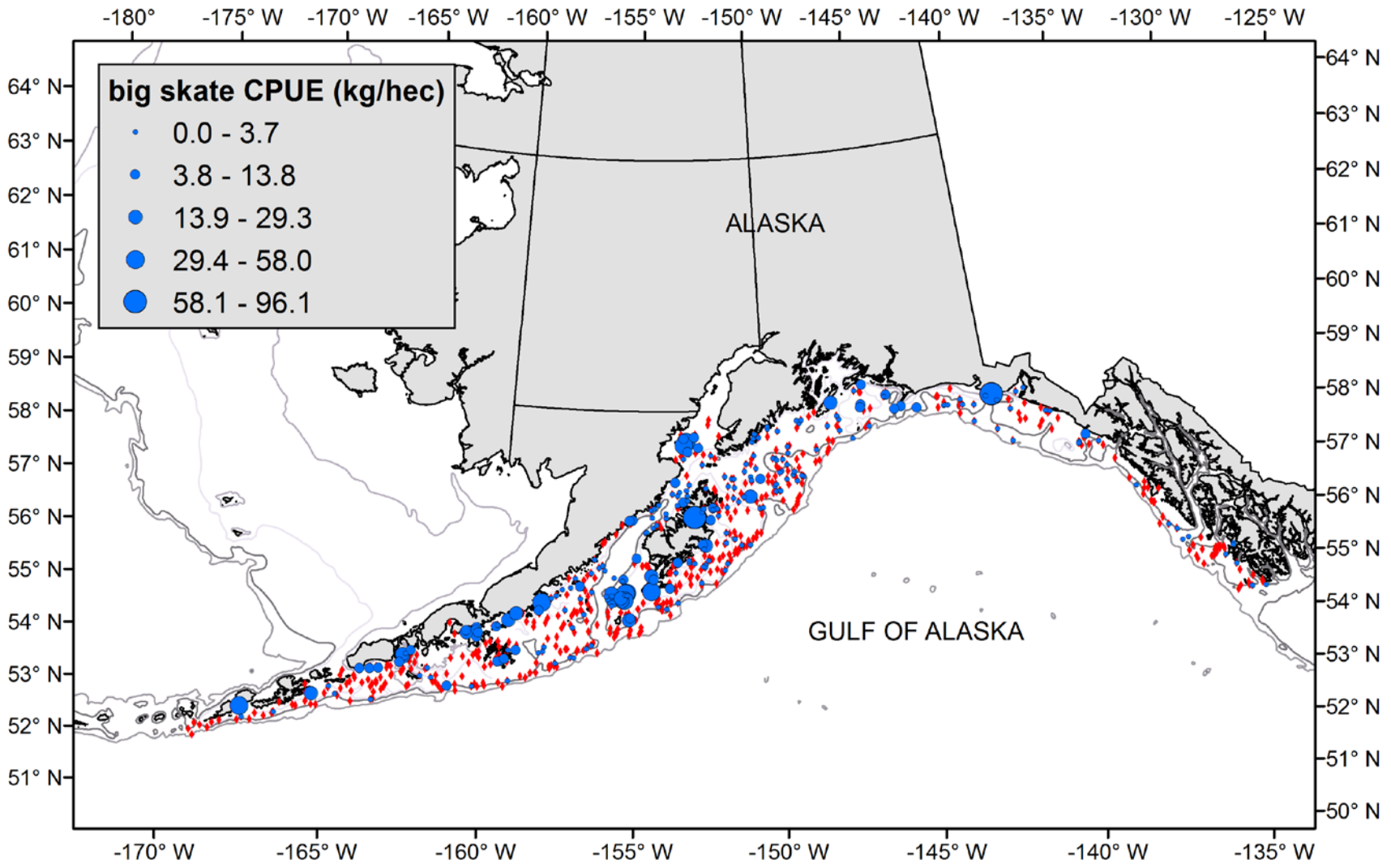

Figure 3. Trawl survey CPUE of **big** skates in 2015. Survey hauls with no skate catch are marked by red diamonds.

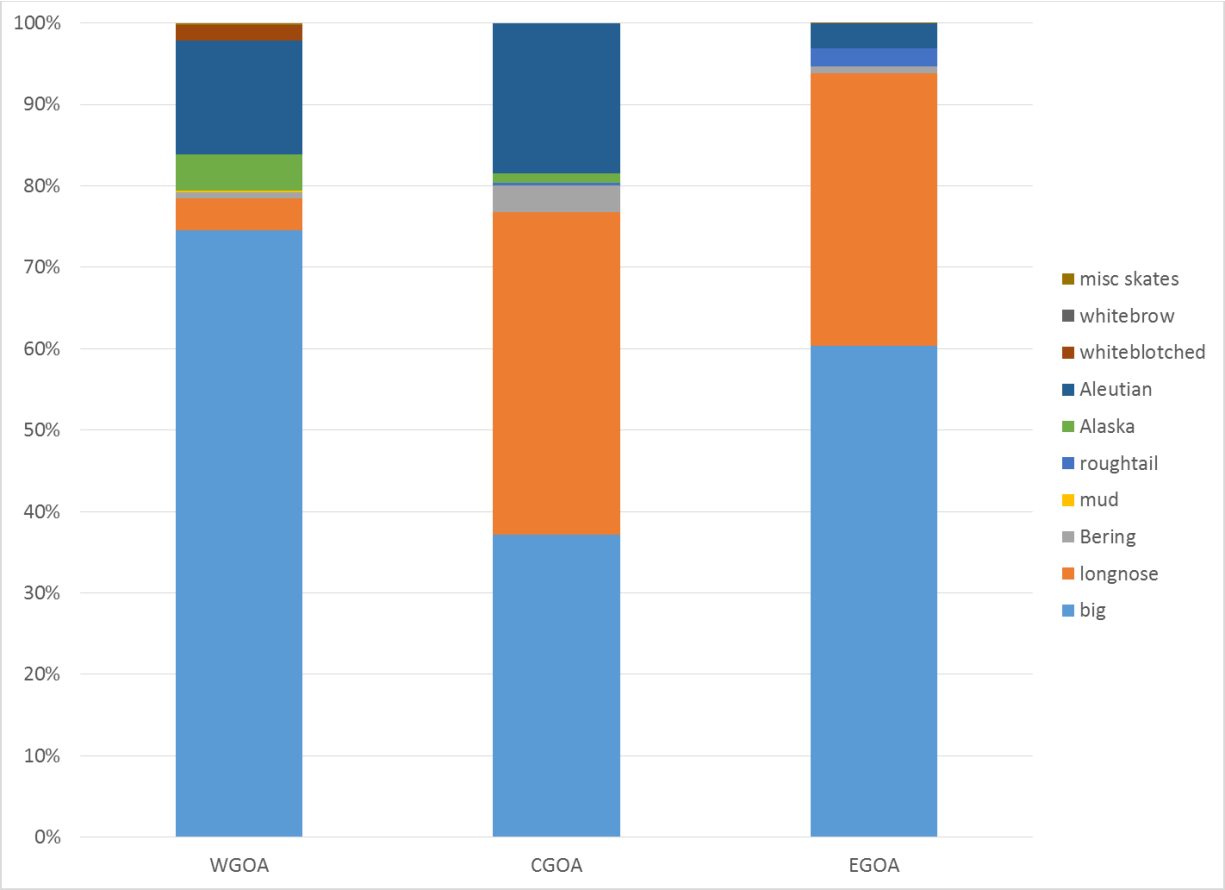

Figure 4. Species composition of GOA skates by GOA regulatory area in 2015.

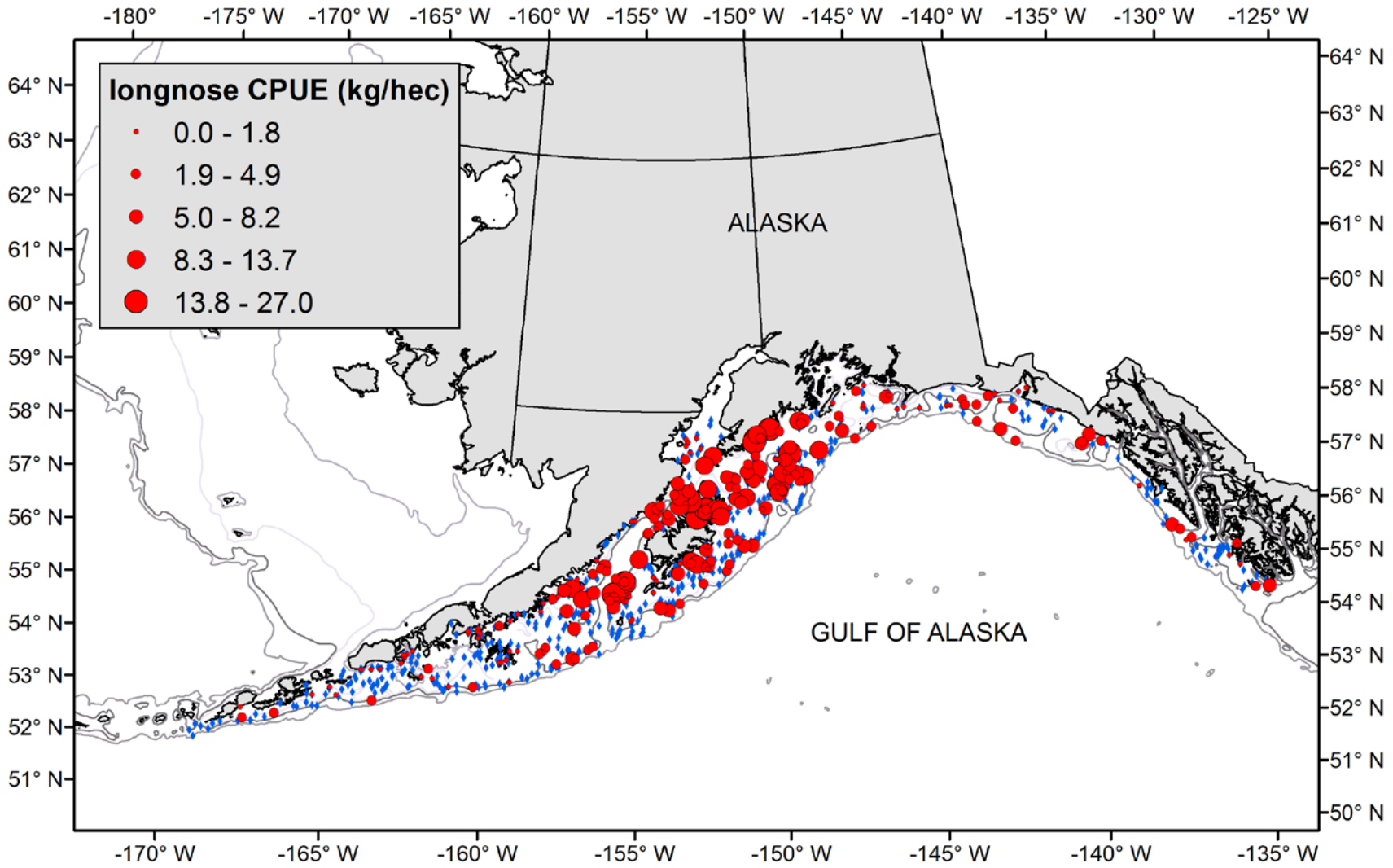

Figure 5. Trawl survey CPUE of **longnose** skates in 2015. Survey hauls with no skate catch are marked by blue diamonds.

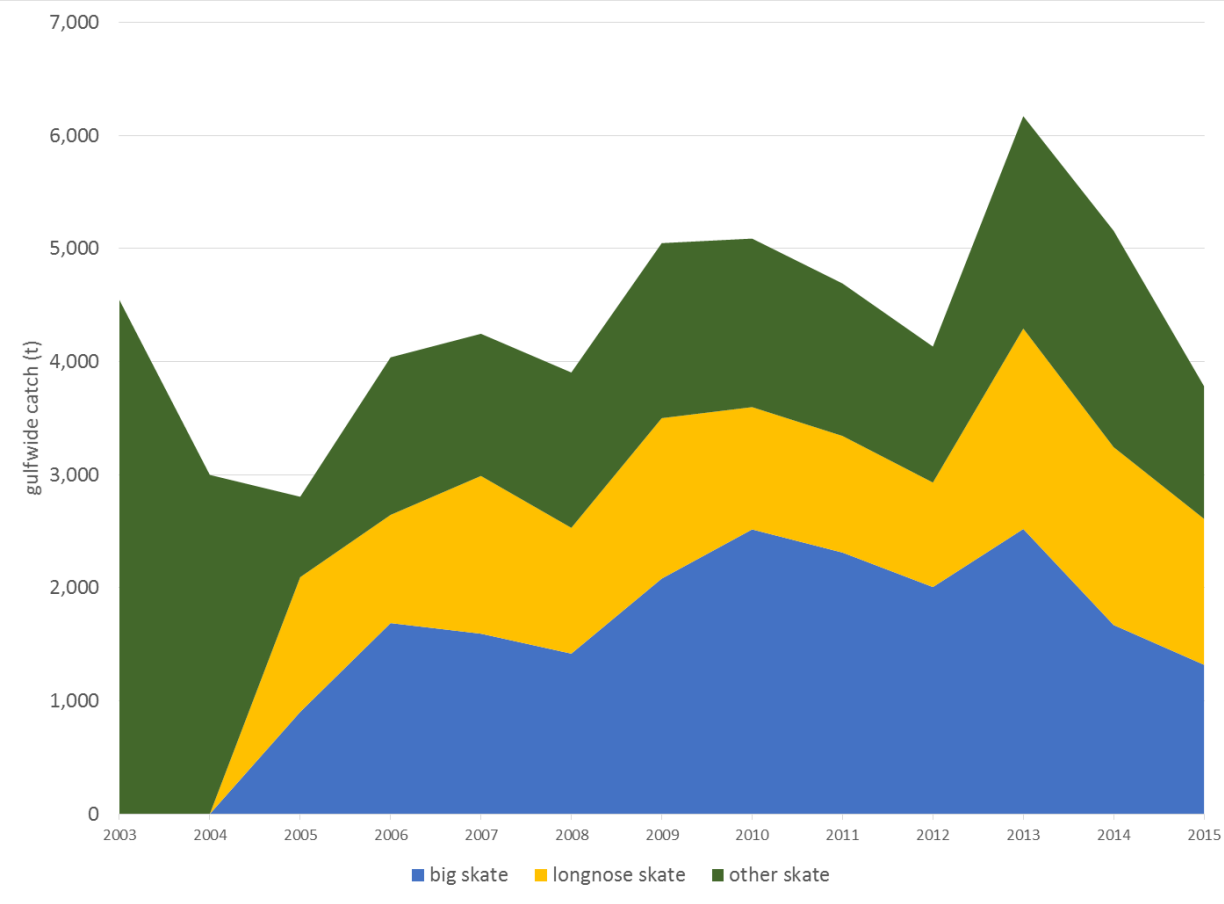

Figure 6. Catch of skates in the GOA, 2003-2015, by species group. Data are from the AK Regional Office. The 2015 data are incomplete; retrieved October 18, 2015.

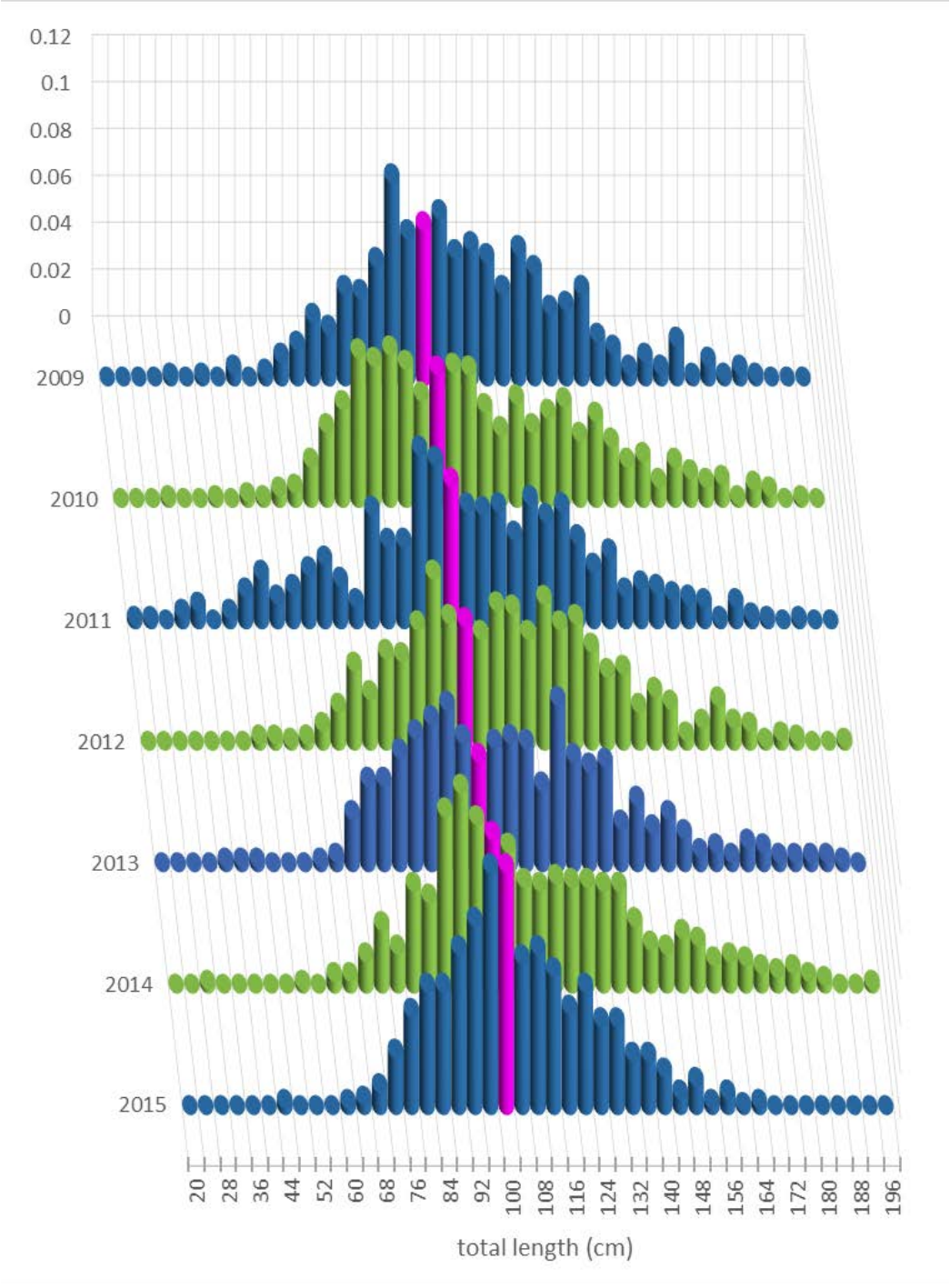

Figure 7. Length compositions of fishery catches (trawl and longline combined) for **big** skates in the GOA, 2009-2015. Data are in 4-cm length bins; fuchsia column indicates the 100-103 cm length bin in each dataset. The 2015 data are incomplete; retrieved October 30, 2015.

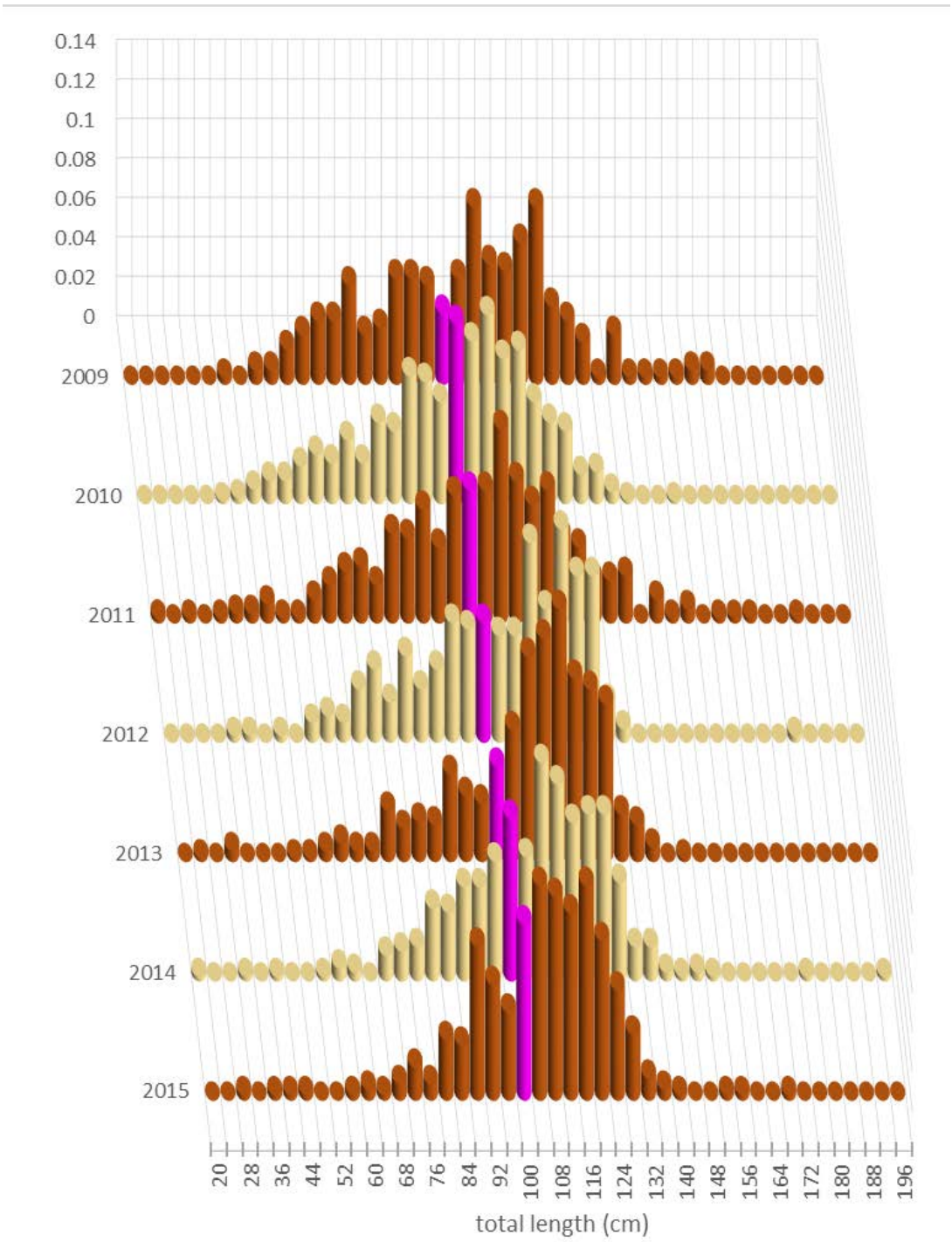

Figure 8. Length compositions of fishery catches (trawl and longline combined) for **longnose** skates in the GOA, 2009-2015. Data are in 4-cm length bins; fuchsia column indicates the 100-103 cm length bin in each dataset. The 2015 data are incomplete; retrieved October 30, 2015.

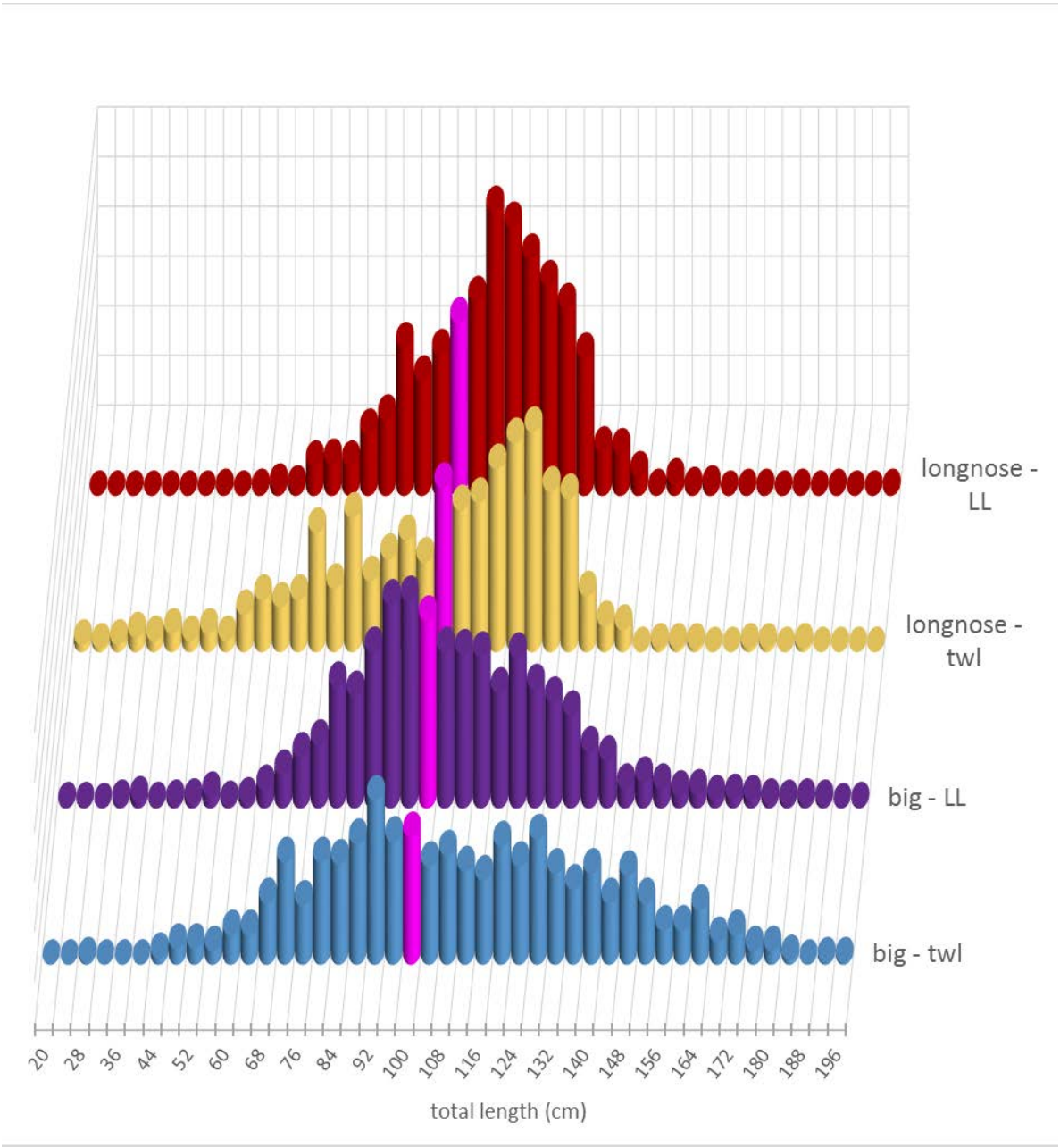

Figure 9. Comparison of trawl and longline fishery length compositions for big and longnose skates in the GOA, all years 2011-2015 combined. Data are in 4-cm length bins; fuchsia column indicates the 100-103 cm length bin in each dataset.

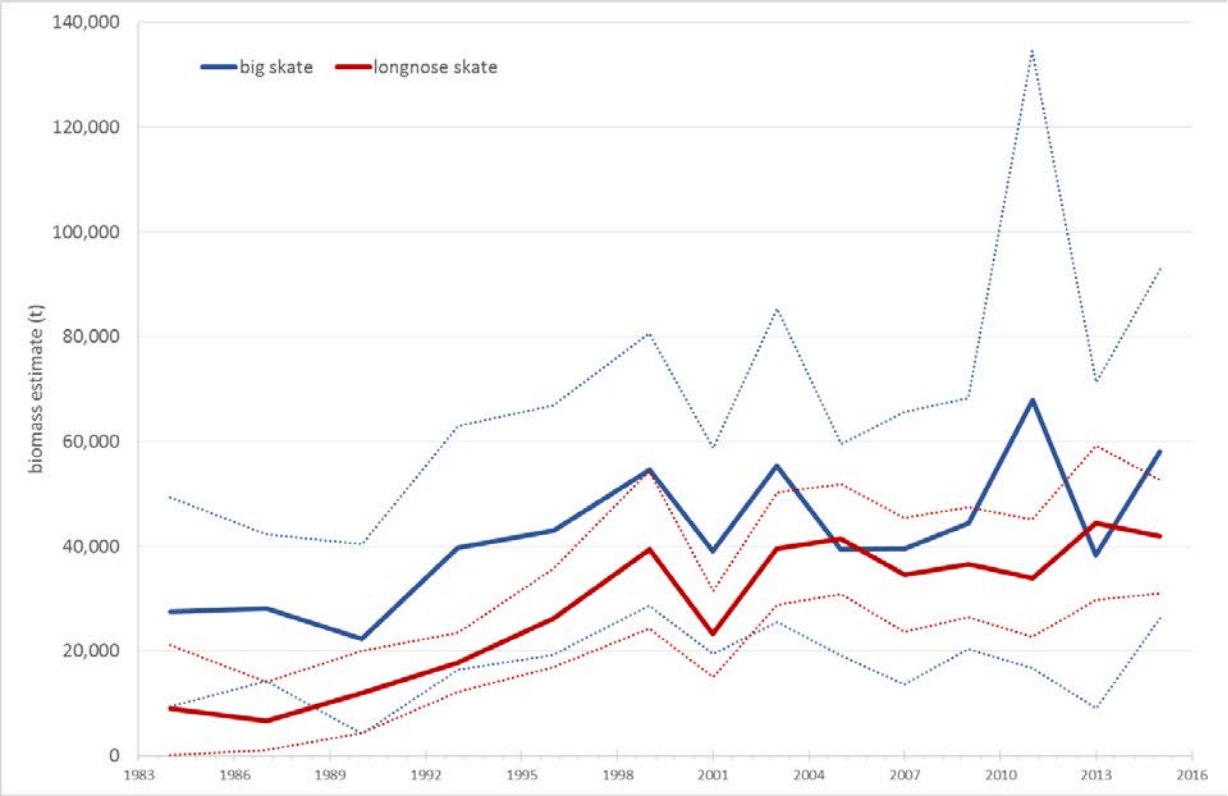

Figure 10. Biomass estimates (t) for big and longnose skates, 1984-2015, from the AFSC bottom trawl survey. Dotted lines (with corresponding colors) indicate 95% confidence intervals.

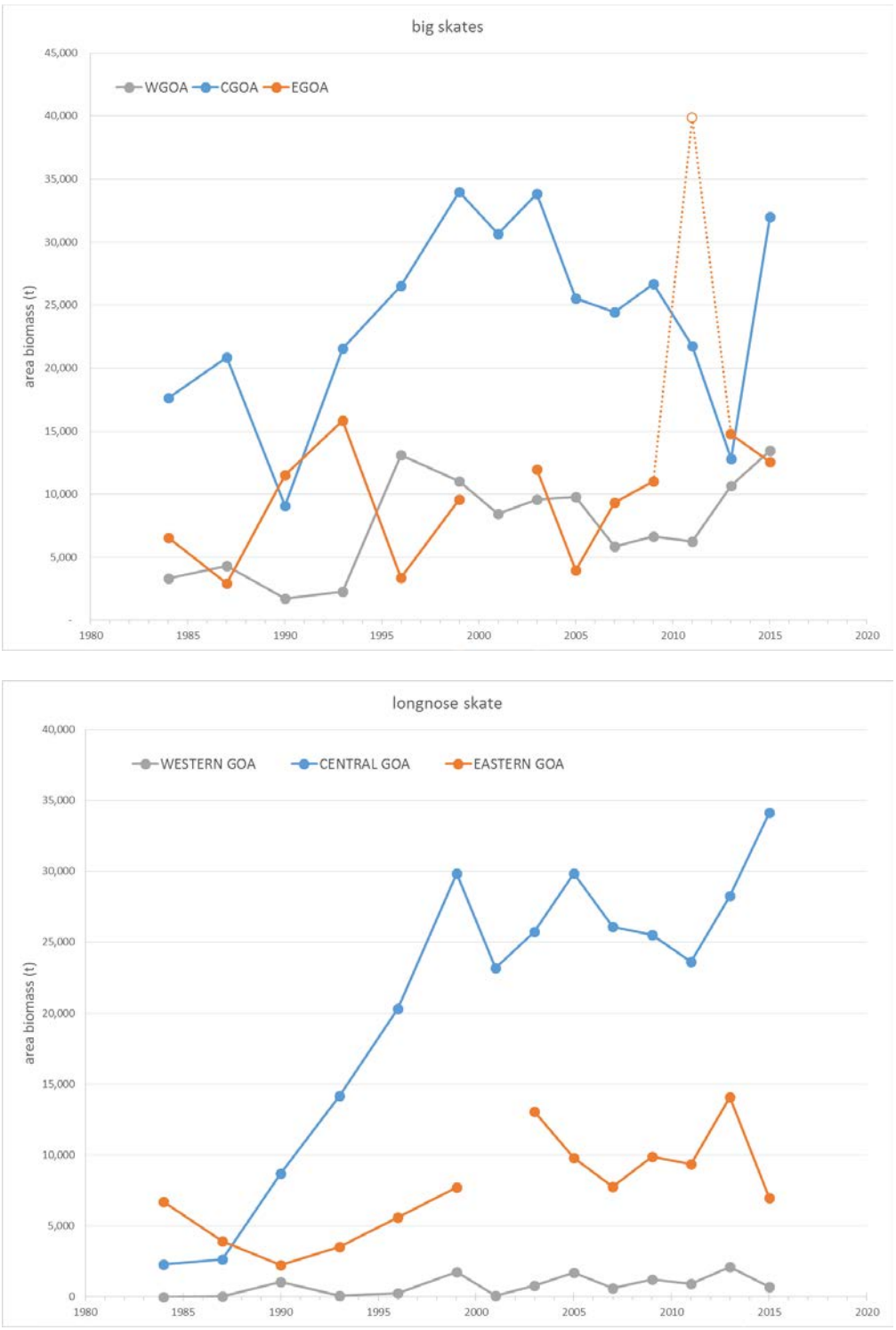

Figure 11. Biomass estimates (t) by regulatory area for big skates (top) and longnose skates (bottom), 1984-2015, from AFSC bottom trawl surveys. Confidence intervals omitted for clarity; see figures 12 & 13 for information on uncertainty. Dotted line and open symbol in the upper plot indicate a 2011 EGOA estimate with a high CV.

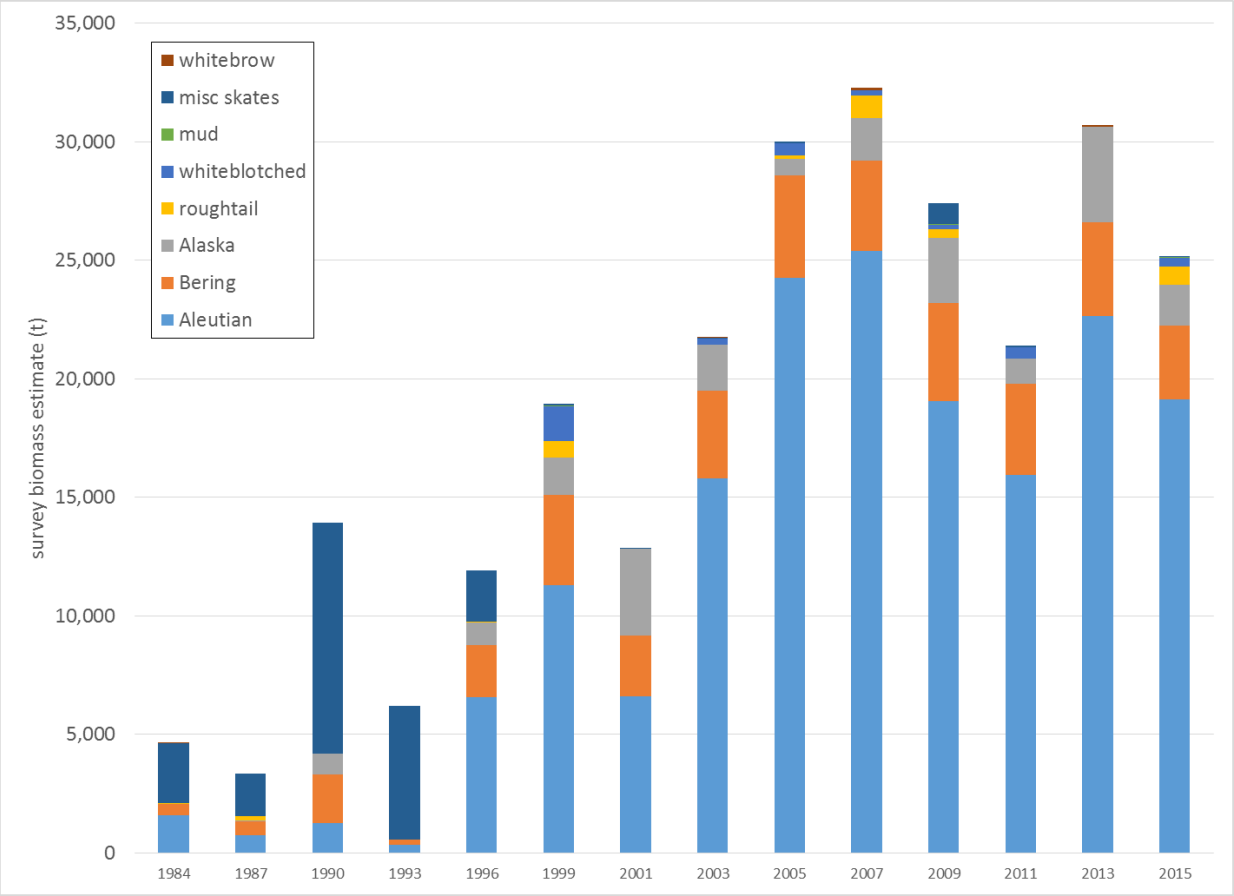

Figure 12. NMFS GOA bottom trawl survey biomass trends for *Bathyraja* skates ("other skates"), 1984-2015. The 2001 survey did not sample in the EGOA. For information regarding the uncertainty of the "other skates" biomass estimate see Figure 14.

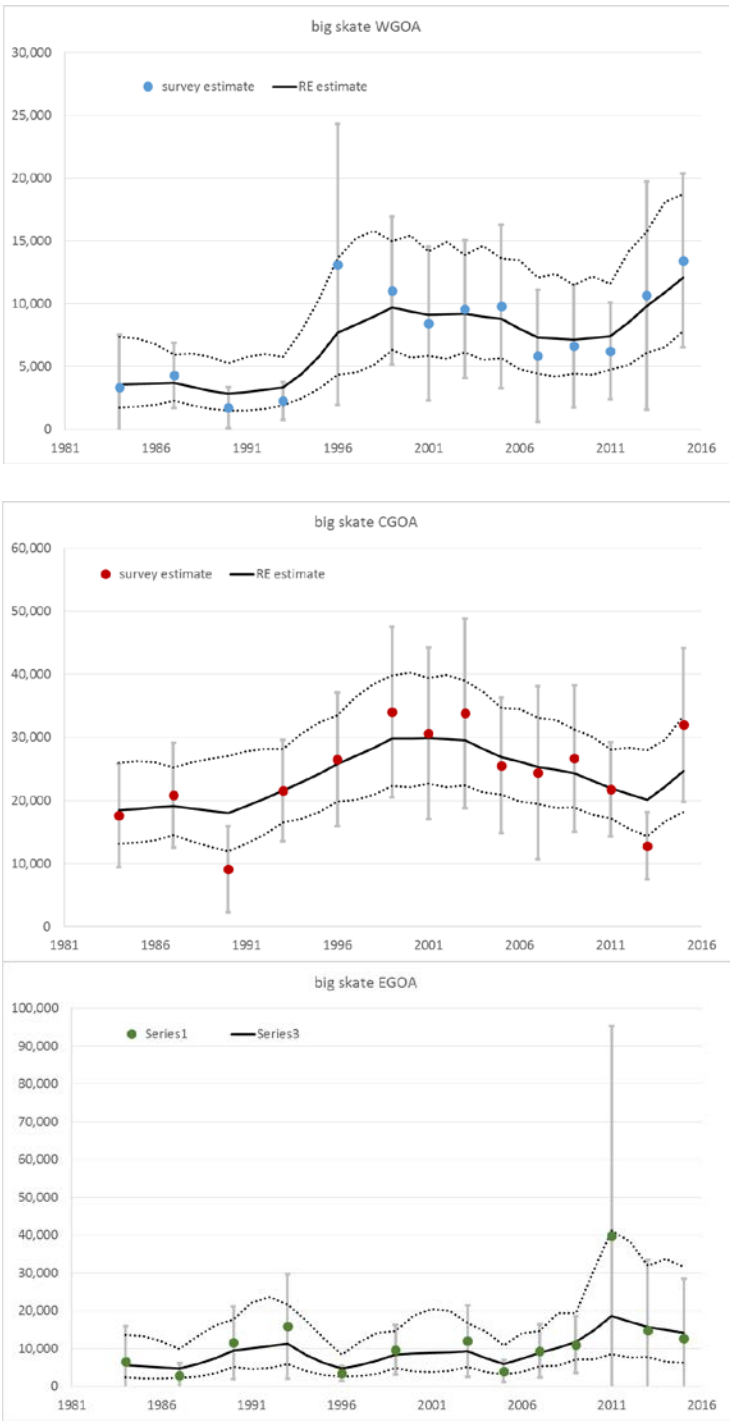

Figure 13. Biomass estimates (t) for **big skates** in 3 GOA regions from the GOA trawl survey (colored dots) and predictions from a random-effects model based on those estimates (black line) for other skates, 1999-2015. 95% confidence intervals are indicated by grey error bars and dotted black lines for the survey and model estimates, respectively.

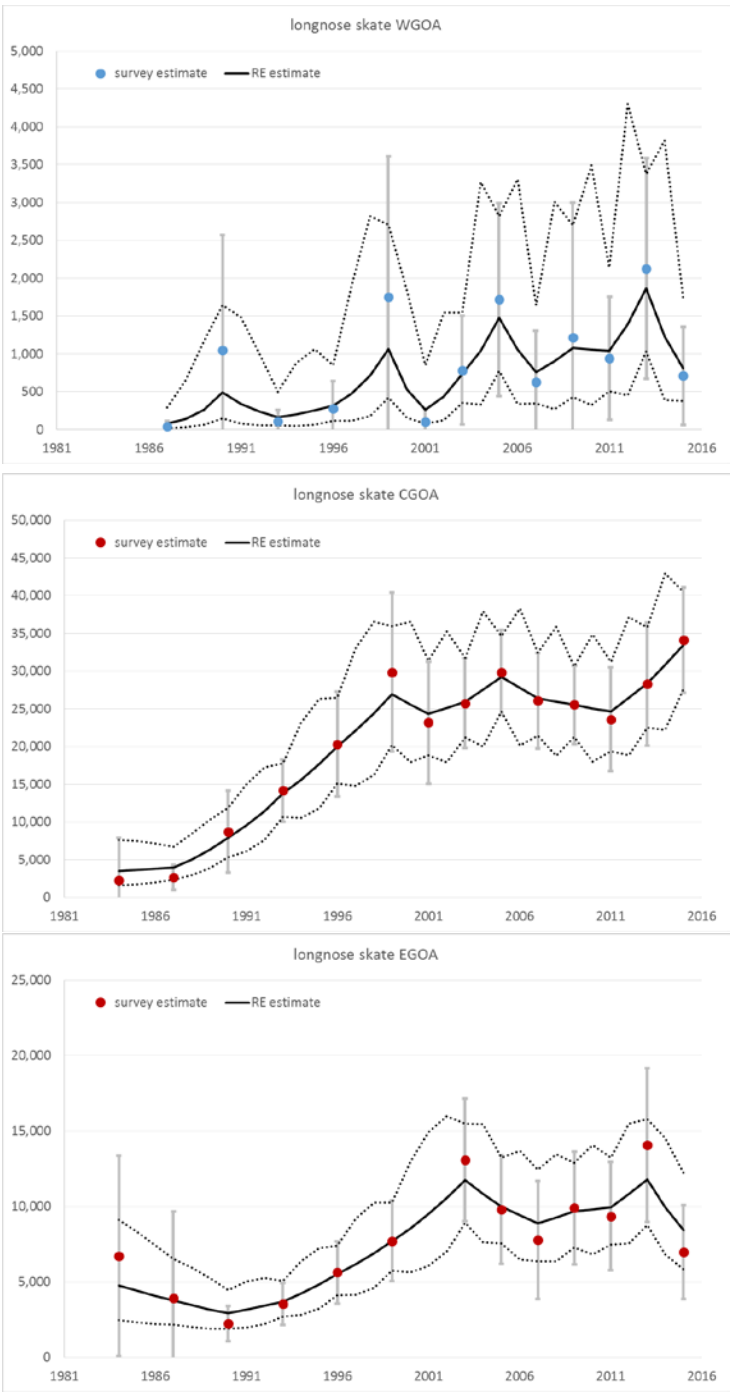

Figure 14. Biomass estimates (t) for **longnose skates** in 3 GOA regions from the GOA trawl survey (colored dots) and predictions from a random-effects model based on those estimates (black line) for other skates, 1999-2015. 95% confidence intervals are indicated by grey error bars and dotted black lines for the survey and model estimates, respectively.

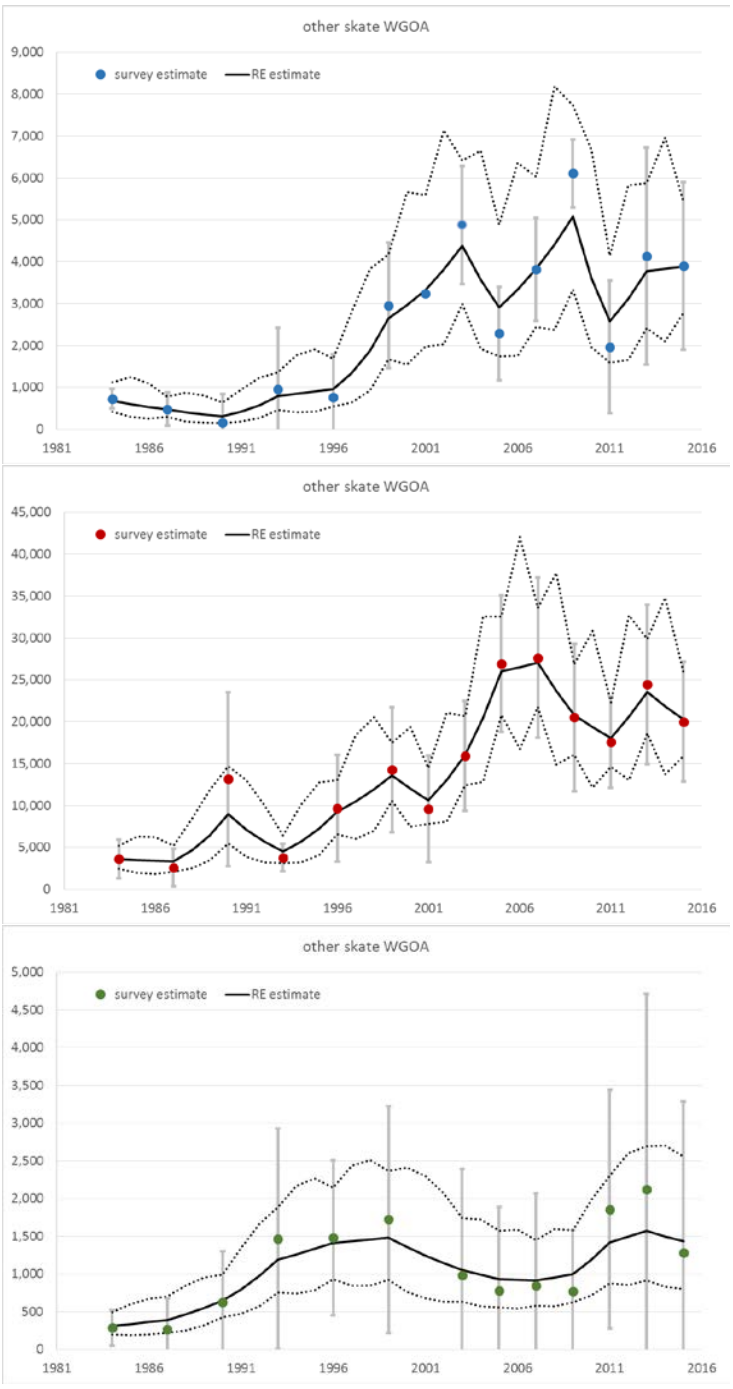

Figure 15. Biomass estimates (t) for **other skates** in 3 GOA regions from the GOA trawl survey (colored dots) and predictions from a random-effects model based on those estimates (black line) for other skates, 1999-2015. 95% confidence intervals are indicated by grey error bars and dotted black lines for the survey and model estimates, respectively.

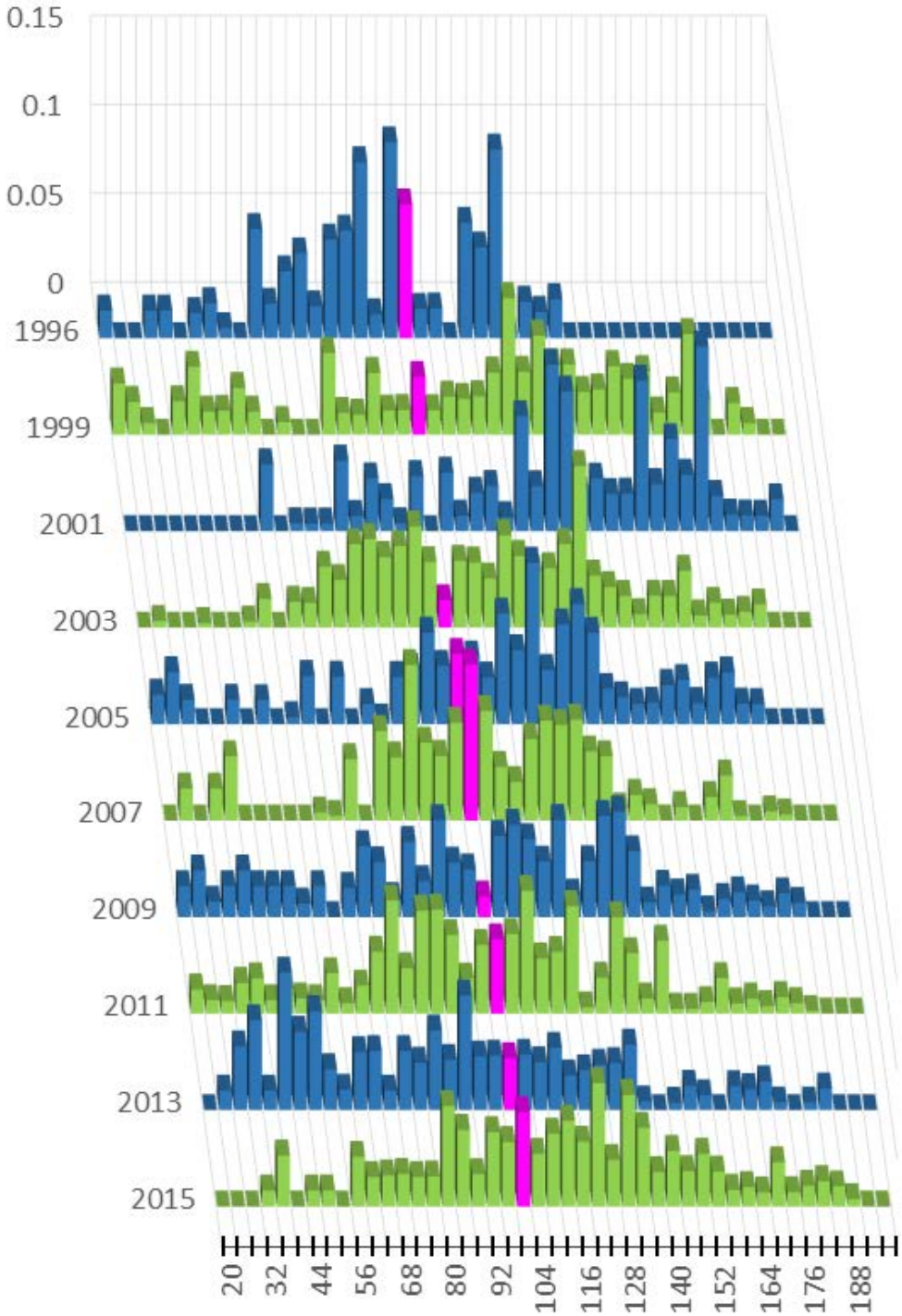

Figure 16. Trawl survey length compositions of **big** skates in the GOA, 1996-2015. Data are in 4-cm length bins; fuchsia column indicates the 100-103 cm length bin in each dataset.

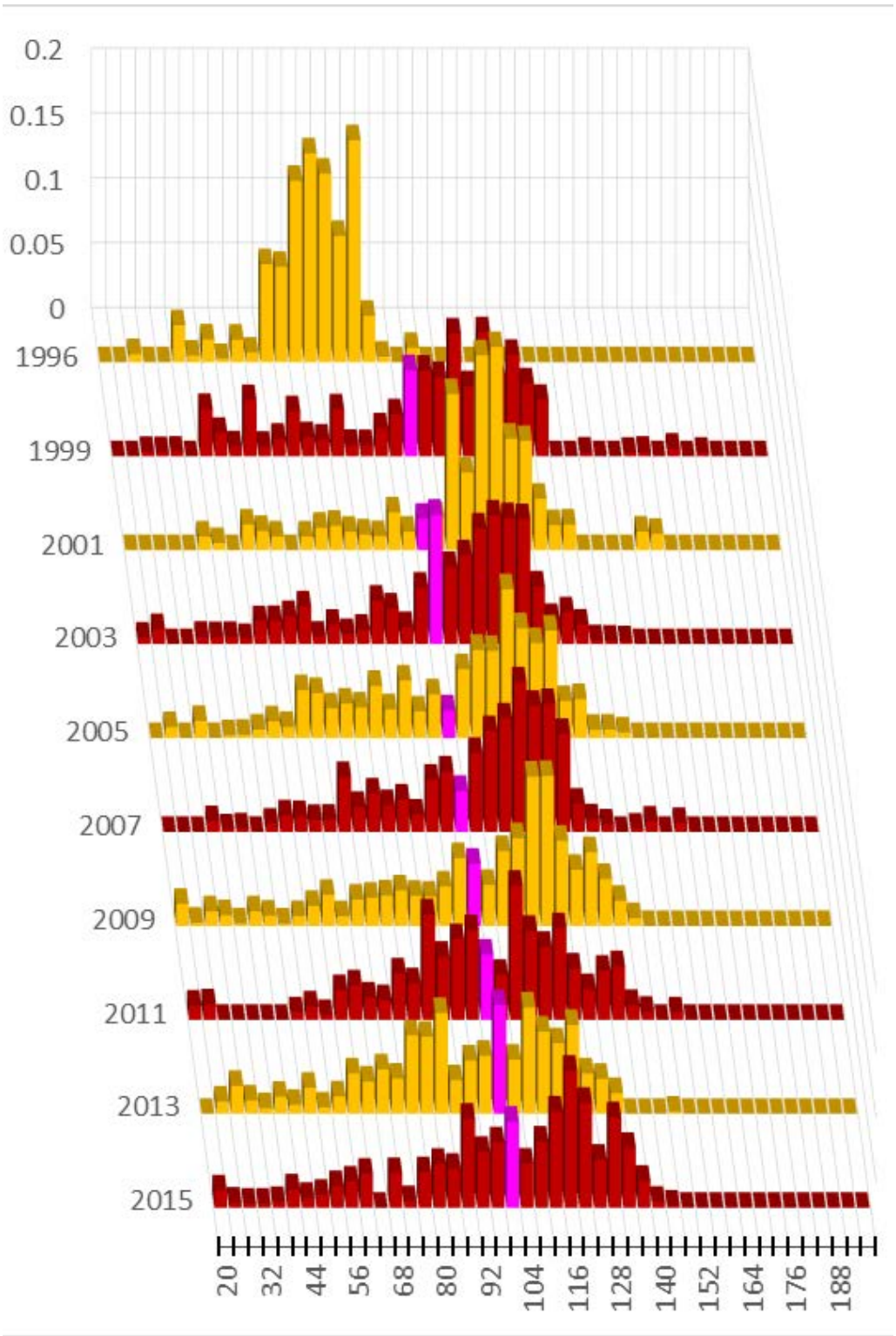

Figure 17. Trawl survey length compositions of **longnose** skates in the GOA, 1996-2015. Data are in 4-cm length bins; fuchsia column indicates the 100-103 cm length bin in each dataset.

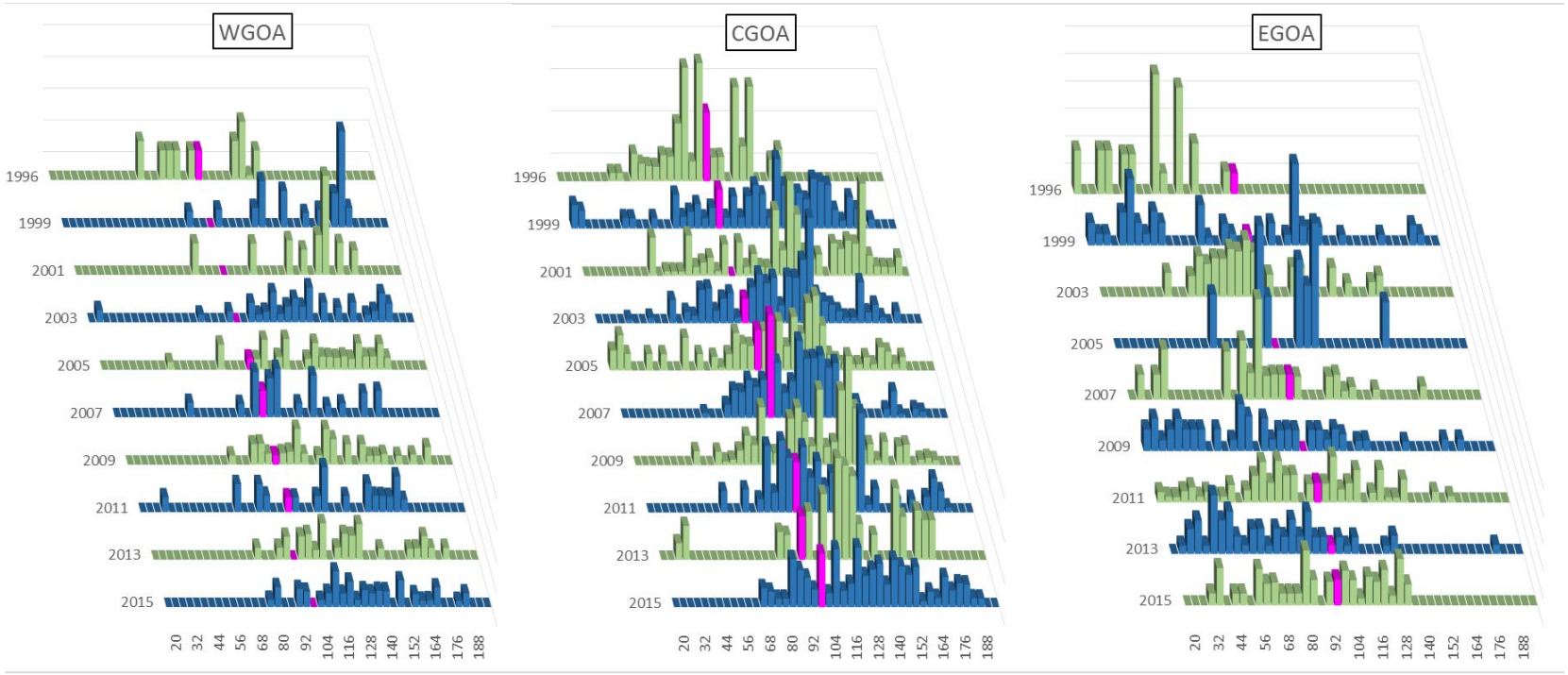

Figure 18. Trawl survey length compositions of **big** skates in the GOA, 1996-2015, by regulatory area. Data are in 4-cm length bins; fuchsia column indicates the 100-103 cm length bin in each dataset.

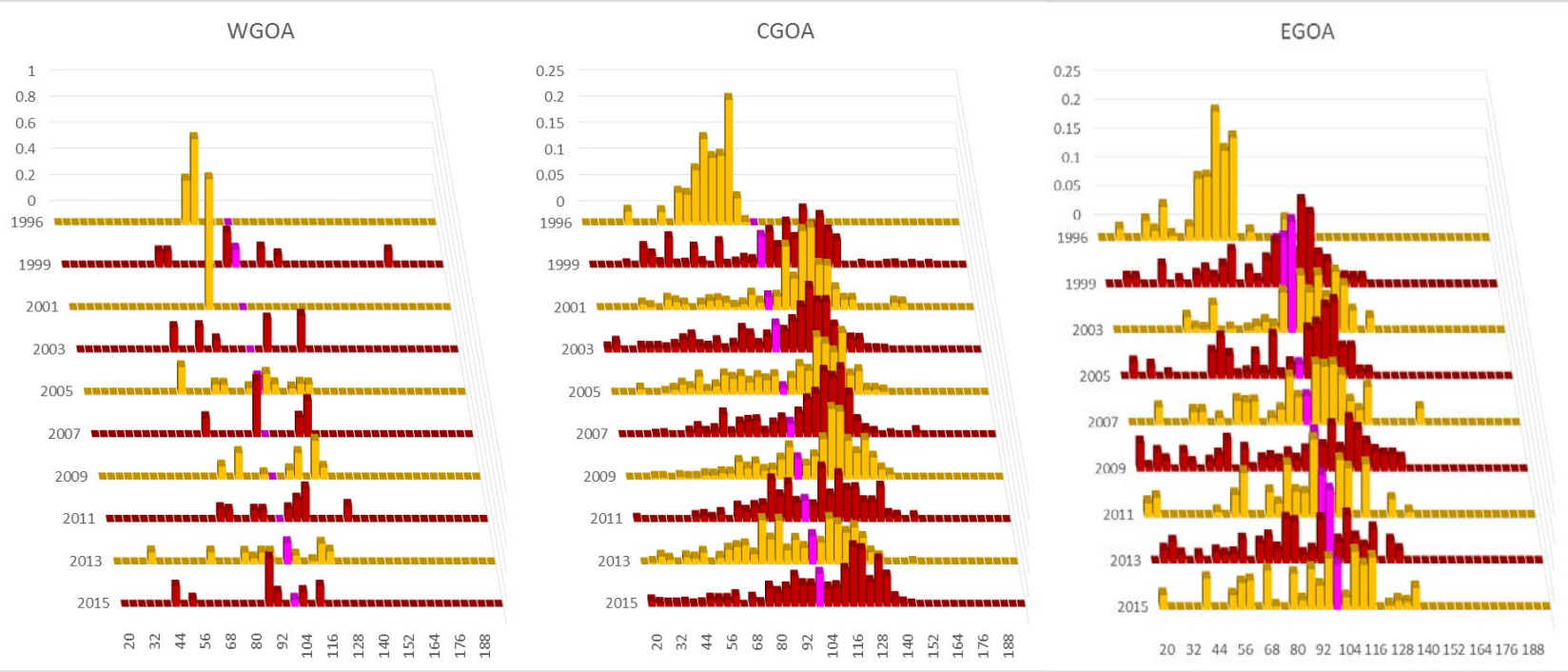

Figure 19. Trawl survey length compositions of **longnose** skates in the GOA, 1996-2015, by regulatory area. Data are in 4-cm length bins; fuchsia column indicates the 100-103 cm length bin in each dataset.

Appendix A: Summary of non-commercial catches. Data are from the AK Regional Office.

Table A-1. Noncommercial catches (kg) of big skates in the GOA.

	Annual Longline Survey	Gulf of Alaska Bottom Trawl Survey	IPHC Annual Longline Survey	Large-Mesh Trawl Survey	Sablefish Longline Survey	Salmon EFP 13-01	Scallop Dredge Survey	Shelikof Acoustic Survey	Shumigans Acoustic Survey	Small-Mesh Trawl Survey	**total**
agency	NMFS	NMFS	IPHC	ADFG	ADFG	NMFS	ADFG	NMFS	NMFS	ADFG	
1999				1,489	22						1,512
2000				1,255	18					96	1,369
2001				744							744
2002				821	17						839
2003				679	25					305	1,009
2004				567	131					445	1,143
2005				924	30		0			172	1,126
2006				1,322	70		0			142	1,534
2007				1,715						36	1,751
2008				670							670
2009	80			609			24				713
2010	369		15,305	6,114				19	39	307	22,153
2011	189	2,542	24,572	6,444						737	34,485
2012	120		26,127	5,519			1			605	32,371
2013	70	1,300	25,562	3,467						127	30,525
2014	130		29,437	522		59					30,147

Table A-2. Noncommercial catches (kg) of longnose skates in the GOA.

	Annual Longline Survey	Golden King Crab Pot Survey	Gulf of Alaska Bottom Trawl Survey	IPHC Annual Longline Survey	Large-Mesh Trawl Survey	Sablefish Longline Survey	Salmon EFP 13-01	Scallop Dredge Survey	Shumigans Acoustic Survey	Small-Mesh Trawl Survey	**total**
agency	NMFS	ADFG	NMFS	IPHC	ADFG	ADFG	NMFS	ADFG	NMFS	ADFG	
1998						2					2
1999					3,418	886					4,304
2000					622	813				70	1,506
2001					2,941	660					3,601
2002					393	643					1,035
2003					2,594	51				255	2,900
2004					891	667				121	1,679
2005					3,028	62		7		398	3,495
2006		8			392	599				280	1,278
2007					1,541					278	1,819
2008					438						438
2009					1,475			10			1,485
2010	11,921			45,818	4,600				14	213	62,566
2011	15,164		1,569	74,655	6,937			13		362	98,700
2012	13,106			59,265	4,352					199	76,922
2013	9,006		1,865	83,970	3,803		85	65		75	98,869
2014	12,651			67,068	1,433		284				81,436

Table A-3. Noncommercial catches (kg) of "other skates" in the GOA.

	Annual Longline Survey	Golden King Crab Pot Survey	Gulf of Alaska Bottom Trawl Survey	IPHC Annual Longline Survey	Large-Mesh Trawl Survey	Sablefish Longline Survey	Salmon EFP 13-01	Scallop Dredge Survey	Shelikof Acoustic Survey	Small-Mesh Trawl Survey	Subsistence Fishery	**total**
agency	NMFS	ADFG	NMFS	IPHC	ADFG	ADFG	NMFS	ADFG	NMFS	ADFG	ADFG	
1984											151	151
1985											1	1
1989											7	7
1990	9,388											9,388
1991	9,697										182	9,879
1992	10,306										158	10,464
1993	11,351										19	11,370
1994	7,307											7,307
1995	19,191											19,191
1996	17,740										57	17,797
1997	20,490										156	20,646
1998	16,121				2,109			10			29	18,269
1999	17,157				1,385							18,542
2000	17,603				408						50	18,062
2001	15,375				1,201			6				16,583
2002	22,079				342			0				22,421
2003	21,302				1,275			10			138	22,725
2004	17,613				409			19				18,041
2005	16,680				1,288	78		33		46		18,124
2006	21,515	3			974			2		162		22,656
2007	30,233				872			33		95		31,233
2008	25,839							7				25,846
2009	11,493				605			67				12,165
2010	828			44,647	4,153			6	47	53		49,733
2011	445		1,328	24,736	3,512			4		49		30,074
2012	1,513			25,744	3,719					53		31,029
2013	651		1,629	24,110	3,109		8	2		53		29,562
2014	277			32,381	3,233					186		36,076