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. Effective January 27, 2016 the Alaska Regional Office indefinitely reduced the maximum retainable amount for all skates in the GOA from 20% to 5%.

Summary of Changes in Assessment Inputs

Changes in the input data:

1) Fully updated fishery catch data (2017 catch data as of October 31, 2017).
2) Biomass estimates and length composition data from the 2017 GOA bottom trawl survey.
3) Fishery length composition data through 2017 (2017 data through October 30, 2017).
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 2016.

Changes in the assessment methodology:

1) No changes were made to the assessment methodology, but the survey data and results sections have been expanded to include a discussion of possible shifts in skate distribution.

Summary of Results

1) Big skate biomass declined substantially from 2015 (2017 random-effects model estimate of 37,975 t relative to the 2015 estimate of 50,857 t). This resulted in a lower OFL and lower area ABCs, particularly in the eastern GOA.

2) The 2017 longnose skate biomass increased from 2015 (47,632 t versus 42,737 t). The area ABCs increased in the western and central GOA but fell slightly in the eastern GOA.

3) The biomass of Other Skates declined from 25,580 t in 2015 to 18,454 t in 2017, resulting in reduced OFL and ABC.

4) Fewer large-sized big skates were encountered in the survey and in fisheries during 2016-2017, and the population appears to be made up of smaller individuals.

5) Unusually, small-sized big skates were more abundant in the central GOA than in the eastern GOA; the reverse is usually the case.

6) Longnose skate appear to have shifted their depth distribution to shallower water: for the first time in the survey they were more abundant in the 1-100 m depth zone than in the 101-200 m zone.

7) The biomass of big skates on the eastern Bering Sea shelf has increased dramatically since 2013. There is strong evidence to suggest that these skates originated in the GOA and that there is exchange between the areas. This movement is likely influencing GOA biomass estimates and may be related to the change in distribution by longnose skates, and to recent warm anomalies in Alaska waters.

The harvest recommendation summary table is on the following pages. 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		*2017*	*2018*	**2018**	2019
M (natural mortality)		*0.1*	*0.1*	**0.1**	0.1
Specified/recommended Tier		*5*	*5*	**5**	5
Biomass (t)	W	*12,112*	*12,112*	**6,716**	6,716
	C	*24,666*	*24,666*	**23,658**	23,658
	E	*14,079*	*14,079*	**7,601**	7,601
	GOA-wide	*50,857*	*50,857*	**37,975**	37,975
F_{OFL} ($F=M$)		*0.1*	*0.1*	**0.1**	0.1
$maxF_{ABC}$ ($F=0.75*M$)		*0.075*	*0.075*	**0.075**	0.075
F_{ABC}		*0.075*	*0.075*	**0.075**	0.075
OFL (t)	GOA-wide	*5,086*	*5,086*	**3,797**	3,797
ABC (t; equal to maximum ABC)	W	*908*	*908*	**504**	504
	C	*1,850*	*1,850*	**1,774**	1,774
	E	*1,056*	*1,056*	**570**	570
Status		As determined *last* year for: 2015	2016	As determined *this* year for: **2016**	2017
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*)					
Quantity		As estimated or *specified last* year for *2017*	*2018*	As estimated or *recommended this* year for: **2018**	2019
M (natural mortality)		*0.1*	*0.1*	**0.1**	0.1
Specified/recommended Tier		*5*	*5*	**5**	5
Biomass (t)	W	*808*	*808*	**1,982**	1,982
	C	*33,503*	*33,503*	**37,390**	37,390
	E	*8,426*	*8,426*	**8,260**	8,260
	GOA-wide	*42,737*	*42,737*	**47,632**	47,632
F_{OFL} (F=M)		*0.1*	*0.1*	**0.1**	0.1
maxF_{ABC} (F=0.75*M)		*0.075*	*0.075*	**0.075**	0.075
F_{ABC}		*0.075*	*0.075*	**0.075**	0.075
OFL (t)	GOA-wide	*4,274*	*4,274*	**4,763**	4,763
ABC (t; equal to maximum ABC)	W	*61*	*61*	**149**	149
	C	*2,513*	*2,513*	**2,804**	2,804
	E	*632*	*632*	**619**	619
Status		As determined *last* year for: 2015	2016	As determined *this* year for: **2016**	2017
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.)					
Quantity		As estimated or *specified last* year for *2017*	*2018*	As estimated or *recommended this* year for: **2018**	2019
M (natural mortality)		*0.1*	*0.1*	**0.1**	0.1
Specified/recommended Tier		*5*	*5*	**5**	5
Biomass (t)	GOA-wide	*25,580*	*25,580*	**18,454**	18,454
F_{OFL} (F=M)		*0.1*	*0.1*	**0.1**	0.1
maxF_{ABC} (F=0.75*M)		*0.075*	*0.075*	**0.075**	0.075
F_{ABC}		*0.075*	*0.075*	**0.075**	0.075
OFL (t)	GOA-wide	*2,558*	*2,558*	**1,845**	1,845
ABC (t; equal to maximum ABC)	GOA-wide	*1,919*	*1,919*	**1,384**	1,384
Status		*As determined last year for:* 2015	2016	As determined *this* year for: **2016**	2017
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

There were no relevant general comments.

Responses to SSC and Plan Team Comments Specific to this Assessment

<u>From the November 2015 Plan Team minutes:</u>

The Team recommended considering the following suggestions for future assessments:

1. Exploring shared process error among areas in RE estimates of biomass.
   Response: This was not explored for the 2017 assessment. The author is interested in working with the RE-model developers to make this change.

2. Examining a more thorough accounting of skate catches in the directed halibut fishery.
   Response: A working group has addressed this issue in the past; as far as the author is aware, revisiting the historical catch data has been delayed until more new data are available as a result of the expansion of observer coverage in the GOA.

3. Including IPHC survey for regional CPUE and apportionment.
   Response: The author considered this but feels that the current approach using the NMFS bottom trawl survey is the best way to address apportionment.

4. Given skate association with depth strata, consider analyzing skate abundance as a function of habitat.
   Response: While this may be possible, it is not clear to the author how this would improve the current biomass estimates. In addition, as this assessment explains there is a change in depth distribution by some skate species. This would interfere with assigning depth preferences to species.

Introduction

<u>Description, scientific names, and general distribution</u>

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 has historically been dominated by big skates (Figure 2). **However, this changed in the 2017 trawl survey, where the estimated biomass in the 1-100 m depth zone was approximately equally distributed between big and longnose skates** (Figure 2). As in past years, longnose skates are the most abundant species in the 101-200 m depth zone, but for the first time in the survey time series the longnose skate biomass is greater in the 1-100 m zone (Figure 3). Skates in the *Bathyraja* genus 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 4 & 5). Longnose skates (Figures 5 & 6) are located further offshore and are relatively less abundant in the western GOA.

<u>Life history and stock structure (skates in general)</u>

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.

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. *Beringraja binoculata* is the largest skate in the GOA, 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). In 2003 skate catches increased dramatically as a result of targeting of skates in the GOA. This was driven by increases in 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 in 2016, and the ABC for longnose skates in the WGOA was exceeded in 4 of the years 2007-2013 (Table 5 and Figure 7). 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). Retention rates of big and longnose skates were high during the late 2000s (Table 7). Retention of all skates 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. The repeated overages were a conservation concern and in January 2016 the Alaska Regional Office indefinitely reduced the maximum retainable amount of all skates from 20% to 5%. Despite this change further prohibitions on retention were required during 2016 (Table 7). As of October no prohibitions on retention were issued in 2017. Although retention rates have declined for all skates, the rate is higher for longnose skates than for the other two groups.

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.

<u>Management units</u>

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

<u>Catch data</u>

Catches from 1992-2003 were estimated using the Alaska Regional Office Blend system (Table 4). Since 2003 skate catch data are recorded in the Alaska Regional Office Catch Accounting System (CAS; Tables 4-7; Figure 7). Additional details are available in the sections above.

<u>Fishery length compositions</u>

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 2009-2017 for big skate (Figure 8) and longnose skate (Figure 9). The 100-103 cm size bin in these figures is colored 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 typically slightly larger than big skates. For both species, a shift in the fishery length composition towards smaller skates is evident in recent years. For big skate this change is most apparent from 2015 to 2017, when the mode of the length shifted from 100 cm to 76 cm (2017 data are incomplete, but the mode during 2016 was 88 cm). The shift in the longnose skate fishery size composition appears to have occurred after 2013, when the length mode was 116 cm. In 2017 a clear mode is not evident but the size distribution is centered on the 100-103 cm length bin. The reasons for this shift are not clear but may be related to issues discussed below in the survey section. Length compositions do not vary substantially among trawl and longline fisheries (Figure 10); 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. Because it has the most comprehensive spatial coverage of the available surveys, for this assessment the NMFS summer bottom trawl surveys 1984-2017 are the primary source of information on the biomass and distribution of the major skate species (Tables 2, 3 & 8; Figures 11-15). On a Gulf-wide basis, the biomass of all three species groups increased during the 1990s (Tables 2, 3 & 8; Figures 11 & 12). Beginning with a high estimate in 2011 (which also had a large variance, due to a single large haul in the EGOA), big skate biomass has fluctuated substantially but the overall trend is decreasing. The biomass of longnose skates has increased substantially since 2011. The Other Skate biomass declined in 2015 and 2017, apparently as a result of reduced abundance of Aleutian skate (Figure 12). Area-specific biomass estimates have shown greater fluctuations (Table 8 & Figure 13-15). While big skate biomass declined in all three areas, the EGOA has seen the greatest relative reduction. The CGOA and WGOA estimates have been highly variable since 2011. Longnose skate biomass estimates in the WGOA have high variance, as that species is less abundant there. Longnose biomass has increased in the CGOA and declined in the EGOA. The decline in Other Skate biomass has occurred mainly in the CGOA.

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 EGOA, 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 EGOA. Intermediate sizes dominate in the CGOA, where a size mode is more distinct than in the other areas. Notably, the smallest skates essentially disappeared from the EGOA length composition in 2017 whereas the CGOA composition had an unusually high number of small skates. 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.

Notable events in 2017

In preparing the 2017 assessment the author noticed a number of changes in the skate data, some of which are unprecedented in the survey time series. These are discussed in more detail below:

1) Loss of large big skates: The fishery and survey length compositions show that the largest sizes of big skates have been relatively less abundant in recent years (Figures 8, 16 & 18). This is most evident in the WGOA but also occurs in the CGOA (Figure 18). A possible explanation for this observation is discussed below. The shift towards a smaller size population can also be seen in the contrast between biomass and abundance data: in the CGOA, where biomass has fluctuated and has a decreasing trend, population numbers are increasing (Figure 20).

2) Small-sized big skates shifted from the EGOA to the CGOA: The smallest sizes of big skates are typically observed in the EGOA (Figure 18). However, they are mostly absent from the 2017 EGOA length composition, and big skate abundance in the EGOA has declined precipitously since 2011 (Figure 20). In contrast, the abundance of small skates has increased in the CGOA. Skates < 36 cm total length, which corresponds approximately to age 0 and age 1 individuals, generally occur in survey hauls in only a few small areas of the CGOA and EGOA: lower Cook Inlet, outside of Prince William Sound, and around Yakutat Bay (Figure 21). This suggests that there may be spawning and/or nursery grounds in these areas. The distribution shift to the west by small skates may indicate greater egg deposition and/or juvenile survival in the CGOA; if so the reasons for this are unclear.

3) Change in depth distribution for longnose skates: As discussed in the introduction, longnose skates are usually most abundant in the 101-200 m depth zone. In the 2017 survey, they were most abundant in the 1-100 m zone (Figure 3). This is the first time this has been observed in the survey time series and may represent a fundamental shift in the relative distribution of skate species. The reason for this change is unknown. Longnose skates may be taking advantage of reduced competition for forage and habitat as the big skate biomass has declined. Alternatively, the warm-water anomaly that has affected many parts of the ecosystem during 2013-2015 may have changed foraging patterns or other behaviors that influence distribution by depth.

4) Possible movement of big skates between the GOA and the eastern Bering Sea (EBS): During the same period (2013-2017) when big skate biomass has fluctuated and declined in the GOA, big skate biomass has increased sharply in the eastern Bering Sea (Figure 22). While there have been episodic high biomass estimates for big skates in the EBS (early 1980s and 1999-2000), the current increase is the largest in the survey data. In addition, the frequency of occurrence of big skates in EBS shelf survey hauls has been particularly high (Figure 23). This is in agreement with the observation that whereas past spikes in EBS big skate biomass have been associated with high CPUEs (Figure 24), the current high estimates are not associated with high big-skate CPUEs. The increased frequency of occurrence in the EBS shelf survey has occurred mainly in the extreme southern portion of the EBS shelf survey area, immediately north of the Alaska Peninsula (Figure 25). The size composition of big skates on the EBS shelf mirrors the size composition in the WGOA (Figure 26), and big skates less than 76 cm are completely absent from the EBS shelf. Taken together these observations suggest that large big skates are shifting from the WGOA to the EBS, and this movement may occur in both directions. In addition, the absence of small skates in the EBS shelf survey suggests that most (if not all) big skates in this region originate in the GOA. The increase in EBS shelf biomass coincides with increased bottom temperature (Figure 27), so it may be that the recent warm-water anomaly has increased thermal habitat for big skates and allowed them to move in the Bering Sea.

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.

To produce biomass estimates suitable for harvest recommendations, biomass was 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 (Table 8; 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. Area-specific 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* requires more exploration; for the time being this assessment continues to use an *M* of 0.1.

Results

Harvest recommendations

big skate (*Beringraja binoculata*)					
		As estimated or *specified last* year for		As estimated or *recommended this* year for:	
Quantity		*2017*	*2018*	**2018**	2019
M (natural mortality)		*0.1*	*0.1*	**0.1**	0.1
Specified/recommended Tier		*5*	*5*	**5**	5
Biomass (t)	W	*12,112*	*12,112*	**6,716**	6,716
	C	*24,666*	*24,666*	**23,658**	23,658
	E	*14,079*	*14,079*	**7,601**	7,601
	GOA-wide	*50,857*	*50,857*	**37,975**	37,975
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	*5,086*	*5,086*	**3,797**	3,797
ABC (t; equal to maximum ABC)	W	*908*	*908*	**504**	504
	C	*1,850*	*1,850*	**1,774**	1,774
	E	*1,056*	*1,056*	**570**	570
Status		As determined *last* year for: 2015	2016	As determined *this* year for: **2016**	2017
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*)					
Quantity		As estimated or *specified last* year for *2017*	*2018*	As estimated or *recommended this* year for: **2018**	2019
M (natural mortality)		*0.1*	*0.1*	**0.1**	0.1
Specified/recommended Tier		*5*	*5*	**5**	5
Biomass (t)	W	*808*	*808*	**1,982**	1,982
	C	*33,503*	*33,503*	**37,390**	37,390
	E	*8,426*	*8,426*	**8,260**	8,260
	GOA-wide	*42,737*	*42,737*	**47,632**	47,632
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	*4,274*	*4,274*	**4,763**	4,763
ABC (t; equal to maximum ABC)	W	*61*	*61*	**149**	149
	C	*2,513*	*2,513*	**2,804**	2,804
	E	*632*	*632*	**619**	619
Status		As determined *last* year for: 2015	2016	As determined *this* year for: **2016**	2017
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.)					
Quantity		As estimated or *specified last* year for *2017*	*2018*	As estimated or *recommended this* year for: **2018**	2019
M (natural mortality)		*0.1*	*0.1*	**0.1**	0.1
Specified/recommended Tier		*5*	*5*	**5**	5
Biomass (t)	GOA-wide	*25,580*	*25,580*	**18,454**	18,454
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	*2,558*	*2,558*	**1,845**	1,845
ABC (t; equal to maximum ABC)	GOA-wide	*1,919*	*1,919*	**1,384**	1,384
Status		*As determined last year for:* 2015	2016	As determined *this* year for: **2016**	2017
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 and for the entire skate complex, 1984-2017. CV = coefficient of variation.

	big skate		**longnose skate**		**Other Skates**		**all skates**	
	biomass	CV	biomass	CV	biomass	CV	biomass	CV
1984	27,540	0.22	9,002	0.38	2,117	0.20	38,660	0.18
1987	28,093	0.16	6,631	0.36	1,666	0.19	36,390	0.14
1990	22,316	0.25	11,995	0.22	4,176	0.20	38,487	0.16
1993	39,733	0.18	17,803	0.12	5,272	0.15	62,808	0.12
1996	43,064	0.18	26,226	0.14	11,768	0.17	81,057	0.11
1999	54,650	0.15	39,333	0.14	18,872	0.12	112,855	0.09
2001	39,082	0.19	23,275	0.16	12,835	0.16	75,192	0.11
2003	55,397	0.16	39,603	0.09	21,739	0.12	116,738	0.09
2005	39,320	0.16	41,370	0.08	29,931	0.11	110,621	0.07
2007	39,630	0.19	34,470	0.11	32,289	0.11	106,388	0.09
2009	44,349	0.16	36,652	0.09	26,510	0.12	107,512	0.08
2011	67,883	0.37	33,911	0.11	21,338	0.10	123,132	0.21
2013	38,234	0.26	44,484	0.11	30,705	0.11	113,423	0.10
2015	58,047	0.17	41,926	0.09	25,150	0.11	125,123	0.09
2017	33,610	0.17	49,501	0.17	17,820	0.13	100,931	0.10

Table 3. Biomass estimates (t) from the AFSC bottom trawl survey in the Gulf of Alaska (GOA) for skates in each GOA regulatory area, 1984-2017.

		1984	1987	1990	1993	1996	1999	2001	2003	2005	2007	2009	2011	2013	2015	2017
	big	3,339	4,313	1,745	2,312	13,130	11,038	8,425	9,602	9,792	5,872	6,652	6,251	10,669	13,449	5,068
	Aleutian	358	112	139	292	82	1,928	1,858	4,401	1,453	3,333	3,051	873	2,970	2,514	3,701
	longnose	0	41	1,045	105	278	1,747	104	782	1,719	628	1,214	941	2,127	708	2,133
	Alaska	0	0	0	0	119	220	1,213	265	211	177	1,728	333	1,124	802	405
	Bering	45	20	28	0	52	218	170	39	86	0	283	237	37	142	255
WGOA	whiteblotched	0	0	0	0	0	544	0	173	502	197	199	487	0	359	96
	Bathyraja sp	0	91	0	651	453	0	0	0	0	0	0	0	0	0	0
	mud	0	0	0	0	0	46	0	0	0	0	10	7	0	43	0
	roughtail	0	0	0	0	43	0	0	0	0	82	0	0	0	0	0
	butterfly	0	0	0	0	0	0	0	0	0	33	0	0	0	0	0
	total WGOA	**3,742**	**4,577**	**2,956**	**3,361**	**14,156**	**15,740**	**11,770**	**15,262**	**13,762**	**10,322**	**13,137**	**9,129**	**16,926**	**18,017**	**11,658**
	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	34,243	39,219
	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	32,038	22,878
	Aleutian	1,235	601	896	60	5,662	8,055	4,734	10,772	22,395	21,928	15,725	13,409	17,972	15,950	9,184
	Bering	230	519	1,861	107	1,511	3,371	2,426	3,526	3,910	3,480	3,370	3,429	3,501	2,788	2,352
	Alaska	0	14	771	0	810	1,272	2,422	1,579	489	1,620	1,021	708	2,907	947	303
CGOA	roughtail	51	182	0	0	0	614	0	0	139	495	356	0	0	326	61
	Bathyraja sp	0	32	0	3,572	1,566	0	12	1	0	16	0	0	0	0	0
	mud	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	whiteblotched	0	0	0	0	0	925	0	0	0	0	0	0	0	0	0
	butterfly	8	0	0	0	0	0	0	0	0	84	0	0	72	0	0
	total CGOA	**21,439**	**24,871**	**21,307**	**39,483**	**56,420**	**78,117**	**63,421**	**75,433**	**82,331**	**78,125**	**72,696**	**62,916**	**65,537**	**86,292**	**73,998**
	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	8,150
	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	5,664
	Bering	187	68	159	119	673	229		136	342	335	473	191	426	180	1,136
	Aleutian	0	25	216	0	796	1,310		640	406	138	295	1,663	1,697	657	326
	Bathyraja sp	0	0	0	470	3	0		0	0	0	0	0	0	1	0
EGOA	mud	0	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	0
	Alaska	4	0	107	0	0	76		63	0	0	0	0	0	0	0
	whiteblotched	0	0	0	0	0	0		91	0	0	0	0	0	0	0
	butterfly	0	0	0	0	0	0		52	0	0	0	0	0	0	0
	total EGOA	**13,478**	**6,941**	**14,224**	**19,964**	**10,482**	**18,998**		**26,043**	**14,528**	**17,941**	**21,678**	**51,087**	**30,960**	**20,814**	**15,275**
GOA-wide		**38,660**	**36,390**	**38,487**	**62,808**	**81,057**	**112,855**	**75,192**	**116,738**	**110,621**	**106,388**	**107,512**	**123,132**	**113,423**	**125,123**	**100,931**

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
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), which do not count towards the TAC. Red-shaded cells with bold text indicate years/areas where the catch exceeded the ABC. * 2017 are incomplete; retrieved October 31, 2017.

	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	69	(118)	
	other				2,093	2,791	313	977	59	(96)	1,349
2012	big	469	1,793	1,505		5,023	65	1,902	38	(62)	
	longnose	70	1,879	676		3,500	39	793	93	(135)	
	other				2,030	2,706	256	843	105	(141)	1,203
2013	big	469	1,793	1,505		5,023	122	2,318	80	(224)	
	longnose	70	1,879	676		3,500	90	1,255	414	(774)	
	other				2,030	2,706	218	1,485	175	(370)	1,878
2014	big	589	1,532	1,641		5,016	156	1,412	103	(233)	
	longnose	107	1,935	834		3,835	59	1,159	338	(559)	
	other				1,989	2,652	305	1,364	236	(492)	1,905
2015	big	589	1,532	1,641		5,016	237	1,224	58	(139)	
	longnose	107	1,935	834		3,835	138	1,176	357	(618)	
	other				1,989	2,652	571	1,039	175	(342)	1,786
2016	big	908	1,850	1,056		5,086	166	1,884	50	(146)	
	longnose	61	2,513	632		4,274	154	887	355	(583)	
	other				1,919	2,558	463	1,045	160	(347)	1,667
2017*	big	908	1,850	1,056		5,086	*154*	*1,259*	*102*	*(187)*	
	longnose	61	2,513	632		4,274	*148*	*708*	*266*	*(476)*	
	other				1,919	2,558	*481*	*823*	*126*	*(234)*	*1,430*

Table 6a. Catches of **big skate** (t) by target fishery, 2005-2017. Data are from the Alaska Regional Office Catch Accounting System. * 2017 are incomplete; retrieved on October 31, 2017.

	big skate												
	2005	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	***2017****
Pacific cod	222	417	536	584	552	928	921	735	611	840	771	638	*556*
IFQ halibut	36	566	11	34	163	42	142	35	420	413	343	673	*509*
arrowtooth	225	163	299	219	433	484	817	677	949	190	237	597	*281*
pollock	2	23	38	22	34	47	93	48	228	171	63	100	*115*
shallow flatfish	251	350	608	413	535	700	190	288	140	26	72	68	*29*
sablefish	23	8	6	5	6	12	2	3	8	3	6	7	*17*
Atka	0	0	0	0	0	0	0	0	0	0	0	1	*3*
rockfish	19	4	0.4	4	4	14	8	13	2	4	7	5	*3*
rex sole	49	99	74	70	264	172	106	149	145	25	19	5	*1*
deep flatfish	0	0	0	0	0	1	1	0	0	0	0	0	*0*
flathead sole	21	30	23	66	53	112	31	57	15	0	2	6	*0*
misc	56	27	0	2	38	5	1	0.2	1	0	0.1	1	*0*
total	903	1,688	1,594	1,418	2,082	2,517	2,312	2,006	2,520	1,671	1,519	2,100	*1,515*

Table 6b. Catches of **longnose skate** (t) by target fishery, 2005-2017. Data are from the Alaska Regional Office Catch Accounting System. * 2017 are incomplete; retrieved on October 31, 2017.

	longnose skate												
	2005	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	***2017****
IFQ halibut	103	186	400	105	421	106	191	114	691	422	502	361	*382*
Pacific cod	139	165	305	359	339	408	334	307	348	415	613	490	*328*
arrowtooth flounder	373	135	165	212	152	166	238	181	218	304	250	273	*163*
sablefish	105	298	277	126	81	109	69	121	321	141	122	153	*161*
rockfish	20	21	17	12	17	12	25	23	23	26	33	46	*39*
pollock	5	13	27	24	35	10	35	9	25	180	87	47	*33*
rex sole	19	29	24	36	82	52	44	45	54	23	21	4	*8*
shallow flatfish	278	97	168	227	239	172	78	65	70	36	26	17	*5*
misc	137	2	0	0.31	30	16	0.25	0	1	0	7	0.39	*3*
flathead sole	11	11	13	11	24	30	17	60	8	11	10	6	*0.31*
Atka	0	0	0	0	0	0	0	0	1	0	0	1	*0.11*
deep flatfish	1	0	0	0.01	0	1	0.35	0	0	0	0	0	*0*
total	1,192	957	1,396	1,112	1,419	1,082	1,032	925	1,760	1,557	1,672	1,397	*1,122*

Table 6c. Catches of **Other Skates** by target fishery (t), 2005-20157. Data are from the Alaska Regional Office Catch Accounting System.
* 2017 are incomplete; retrieved October 31, 2017.

Other Skates															
	2003	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	***2017****
Pacific cod	816	904	175	980	527	945	887	1,058	776	686	805	935	1,079	983	*861*
IFQ halibut	169	128	47	74	109	32	256	37	142	101	683	523	290	258	*191*
arrowtooth flounder	209	376	194	64	123	88	99	133	242	174	63	164	118	234	*168*
sablefish	156	225	122	124	262	144	89	133	117	148	199	170	178	150	*166*
rockfish	106	67	59	49	20	10	13	28	15	20	18	45	21	18	*22*
shallow flatfish	562	328	36	27	79	107	98	35	20	33	44	28	30	17	*10*
pollock	10	3	1	5	9	6	3	7	2	6	24	17	18	4	*5*
rex sole	346	89	36	56	103	22	60	41	21	20	33	21	13	0.16	*3*
misc	1,971	782	2	3	4	16	30	0	0	0	0.03	0	30	0	*2*
Atka	0	0	0	0	0	0	0	0.05	2	0	0.00	0	0	0	*1*
deep flatfish	0.41	8	0	0	0	0	0	0.08	0	0	0	1	0	0	*0*
flathead sole	200	89	38	12	20	5	13	19	13	17	8	1	8	3	*0*
total	4,546	2,999	711	1,393	1,257	1,374	1,548	1,491	1,349	1,203	1,878	1,905	1,786	1,667	*1,430*

Table 7. Retention rates of skates in GOA fisheries, 2007-2017. Data are from the NMFS Alaska Regional Office. Retention rates in 2013-2017 were influenced by management actions; see footnotes.

	big	longnose	other
2005	72%	70%	16%
2006	54%	32%	19%
2007	49%	29%	20%
2008	70%	59%	15%
2009	70%	45%	13%
2010	71%	64%	15%
2011	80%	61%	17%
2012	94%	71%	13%
2013[1]	62%	38%	2%
2014[2]	26%	55%	5%
2015[3]	16%	52%	6%
2016[4+]	32%	33%	6%
*2017[5]**	*35%*	*28%*	*7%*
2005-2017 average	58%	48%	28%

[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.
[4] The following management actions related to skates in the GOA occurred during 2016:

- retention of longnose skates in the WGOA was prohibited on April 25, 2016.
- retention of big skates in the CGOA was prohibited on September 27, 2016.

[+]Effective January 27, 2016 the maximum retention allowance for skates (all species, GOA-wide) was reduced to 5%.
[5] On September 20, 2017 retention of longnose skates in the WGOA was prohibited.

* 2017 data are incomplete; retrieved October 31, 2017

Table 8a. Biomass estimates (t) and coefficients of variation (CV) for **big skates** in 3 regions of the Gulf of Alaska. Estimates are annual trawl survey estimates (survey) or estimates from a random effects model fitted to each survey time series (RE model).

	WGOA				CGOA				EGOA			
	survey		RE model		survey		RE model		survey		RE model	
	biomass	CV	biomass	CV	biomass	CV	biomass	CV	biomass	CV	biomass	CV
1984	3,339	0.56	3,573	0.38	17,635	0.23	18,601	0.17	6,566	0.56	5,642	0.45
1985			3,627	0.36			18,811	0.17			5,262	0.47
1986			3,681	0.32			19,023	0.16			4,907	0.45
1987	4,313	0.29	3,737	0.25	20,855	0.19	19,238	0.14	2,925	0.45	4,577	0.39
1988			3,379	0.30			18,981	0.16			5,849	0.42
1989			3,056	0.33			18,728	0.18			7,475	0.40
1990	1,745	0.45	2,763	0.33	9,071	0.34	18,478	0.19	11,501	0.38	9,554	0.32
1991			2,930	0.35			19,496	0.18			10,146	0.41
1992			3,107	0.34			20,570	0.16			10,776	0.41
1993	2,312	0.32	3,294	0.29	21,586	0.18	21,703	0.13	15,836	0.36	11,444	0.33
1994			4,408	0.31			22,938	0.14			8,439	0.39
1995			5,898	0.31			24,244	0.14			6,222	0.37
1996	13,130	0.40	7,892	0.30	26,544	0.19	25,624	0.13	3,391	0.29	4,588	0.29
1997			8,499	0.32			26,802	0.14			5,617	0.38
1998			9,153	0.30			28,033	0.15			6,877	0.38
1999	11,038	0.26	9,857	0.22	34,007	0.20	29,321	0.14	9,606	0.33	8,419	0.28
2000			9,483	0.26			29,412	0.15			8,636	0.41
2001	8,425	0.34	9,122	0.23	30,658	0.21	29,504	0.14			8,859	0.44
2002			9,189	0.26			29,327	0.14			9,087	0.41
2003	9,602	0.28	9,257	0.21	33,814	0.21	29,151	0.14	11,981	0.37	9,322	0.31
2004			9,029	0.26			27,971	0.14			7,352	0.35
2005	9,792	0.32	8,806	0.23	25,544	0.21	26,839	0.12	3,984	0.35	5,798	0.31
2006			7,992	0.27			26,084	0.13			7,162	0.35
2007	5,872	0.42	7,253	0.26	24,420	0.26	25,350	0.13	9,337	0.33	8,847	0.26
2008			7,137	0.28			24,782	0.13			10,162	0.33
2009	6,652	0.36	7,022	0.25	26,691	0.21	24,227	0.12	11,007	0.31	11,672	0.26
2010			7,115	0.27			23,140	0.13			14,638	0.38
2011	6,251	0.30	7,210	0.23	21,761	0.17	22,102	0.12	39,870	0.57	18,358	0.42
2012			8,161	0.27			21,231	0.14			16,291	0.43
2013	10,669	0.40	9,238	0.25	12,810	0.20	20,395	0.16	14,755	0.52	14,458	0.36
2014			9,843	0.27			22,145	0.13			12,695	0.40
2015	13,449	0.24	10,487	0.22	32,038	0.19	24,046	0.13	12,560	0.53	11,147	0.36
2016			8,392	0.26			23,851	0.14			9,205	0.41
2017	5,068	0.29	6,716	0.26	22,878	0.21	23,658	0.15	5,664	0.47	7,601	0.40

Table 8b. Biomass estimates (t) and coefficients of variation (CV) for **longnose skates** in 3 regions of the Gulf of Alaska. Estimates are annual trawl survey estimates (survey) or estimates from a random effects model fitted to each survey time series (RE model).

	WGOA				CGOA				EGOA			
	survey		RE model		survey		RE model		survey		RE model	
	biomass	CV	biomass	CV	biomass	CV	biomass	CV	biomass	CV	biomass	CV
1984					2,280	0.68	3,555	0.39	6,722	0.42	4,691	0.32
1985							3,698	0.36			4,355	0.32
1986							3,848	0.32			4,044	0.30
1987	41	0.72	78	0.69	2,667	0.30	4,003	0.27	3,923	0.53	3,754	0.27
1988			142	0.76			5,033	0.27			3,465	0.27
1989			258	0.74			6,328	0.25			3,198	0.25
1990	1,045	0.64	471	0.61	8,708	0.28	7,956	0.20	2,242	0.25	2,952	0.21
1991			334	0.73			9,547	0.22			3,190	0.23
1992			237	0.71			11,456	0.20			3,446	0.21
1993	105	0.64	168	0.56	14,158	0.15	13,746	0.13	3,539	0.19	3,723	0.16
1994			207	0.72			15,569	0.20			4,245	0.20
1995			256	0.71			17,633	0.20			4,840	0.20
1996	278	0.59	317	0.50	20,328	0.17	19,971	0.14	5,620	0.18	5,519	0.15
1997			470	0.69			22,035	0.20			6,161	0.20
1998			698	0.68			24,312	0.20			6,879	0.20
1999	1,747	0.49	1,035	0.47	29,872	0.17	26,824	0.15	7,714	0.17	7,681	0.15
2000			532	0.61			25,550	0.18			8,528	0.21
2001	104	0.64	273	0.60	23,171	0.16	24,336	0.13			9,470	0.22
2002			449	0.62			25,135	0.17			10,515	0.20
2003	782	0.43	737	0.37	25,741	0.12	25,959	0.10	13,081	0.15	11,676	0.14
2004			1,036	0.56			27,518	0.16			10,802	0.17
2005	1,719	0.35	1,455	0.33	29,853	0.09	29,170	0.09	9,797	0.18	9,993	0.14
2006			1,055	0.56			27,747	0.16			9,455	0.18
2007	628	0.44	765	0.39	26,083	0.12	26,392	0.11	7,759	0.24	8,947	0.17
2008			905	0.59			25,958	0.16			9,305	0.18
2009	1,214	0.58	1,071	0.46	25,534	0.10	25,530	0.09	9,904	0.18	9,678	0.14
2010			1,058	0.59			25,094	0.16			9,815	0.18
2011	941	0.41	1,046	0.37	23,609	0.14	24,666	0.12	9,362	0.19	9,954	0.14
2012			1,396	0.55			26,505	0.17			10,772	0.18
2013	2,127	0.32	1,864	0.30	28,274	0.14	28,481	0.12	14,083	0.17	11,657	0.15
2014			1,307	0.55			31,081	0.16			9,914	0.18
2015	708	0.41	917	0.38	34,243	0.10	33,919	0.09	6,975	0.22	8,431	0.16
2016			1,348	0.55			35,612	0.18			8,345	0.20
2017	2,133	0.30	1,982	0.30	39,219	0.20	37,390	0.17	8,150	0.22	8,260	0.18

Table 8c. Biomass estimates (t) and coefficients of variation (CV) for **Other Skates** in 3 regions of the Gulf of Alaska. Estimates are annual trawl survey estimates (survey) or estimates from a random effects model fitted to each survey time series (RE model).

	WGOA				**CGOA**				**EGOA**			
	survey		**RE model**		**survey**		**RE model**		**survey**		**RE model**	
	biomass	**CV**	**biomass**	**CV**	**biomass**	**CV**	**biomass**	**CV**	**biomass**	**CV**	**biomass**	**CV**
1984	403	0.41	352	0.35	1,524	0.25	1,534	0.23	190	0.21	189	0.20
1985			317	0.40			1,545	0.29			186	0.31
1986			286	0.39			1,557	0.28			184	0.35
1987	223	0.40	258	0.32	1,349	0.22	1,568	0.20	94	0.44	181	0.34
1988			262	0.40			1,984	0.27		0.26	242	0.34
1989			266	0.41			2,510	0.27		0.32	322	0.31
1990	167	0.43	270	0.35	3,528	0.23	3,176	0.19	481	0.26	429	0.22
1991			381	0.39			3,450	0.27			493	0.30
1992			538	0.37			3,749	0.26			567	0.31
1993	944	0.32	759	0.27	3,739	0.19	4,073	0.17	590	0.31	652	0.25
1994			820	0.36			5,293	0.26			816	0.31
1995			886	0.37			6,880	0.26			1,021	0.30
1996	748	0.35	957	0.29	9,548	0.20	8,942	0.17	1,471	0.38	1,277	0.23
1997			1,339	0.36			10,236	0.26			1,333	0.31
1998			1,872	0.35			11,719	0.25			1,391	0.32
1999	2,955	0.26	2,617	0.23	14,238	0.14	13,415	0.13	1,679	0.47	1,452	0.26
2000			2,940	0.32			12,045	0.22			1,328	0.34
2001	3,241	0.35	3,302	0.26	9,593	0.17	10,815	0.15			1,215	0.36
2002			3,781	0.31			13,174	0.22			1,111	0.34
2003	4,878	0.21	4,330	0.19	15,879	0.14	16,048	0.13	982	0.32	1,017	0.28
2004			3,565	0.30			20,360	0.21			950	0.32
2005	2,250	0.32	2,935	0.26	26,934	0.12	25,832	0.11	747	0.34	888	0.29
2006			3,320	0.31			26,354	0.21			887	0.31
2007	3,823	0.28	3,757	0.23	27,622	0.12	26,887	0.11	844	0.35	886	0.25
2008			4,131	0.30			23,654	0.21			923	0.29
2009	5,271	0.22	4,542	0.20	20,472	0.14	20,809	0.13	767	0.44	961	0.25
2010			3,415	0.30			19,432	0.21			1,189	0.29
2011	1,937	0.27	2,567	0.24	17,546	0.11	18,145	0.11	1,855	0.38	1,471	0.26
2012			3,098	0.31			20,569	0.21			1,552	0.31
2013	4,130	0.27	3,739	0.22	24,453	0.13	23,317	0.12	2,122	0.51	1,636	0.29
2014			3,815	0.29			21,311	0.21			1,533	0.31
2015	3,859	0.18	3,891	0.16	20,012	0.13	19,477	0.12	1,279		1,436	0.28
2016			4,102	0.29			15,718	0.22			1,441	0.35
2017	4,457	0.27	4,324	0.24	11,901	0.15	12,684	0.14	1,462		1,446	0.36

Figures

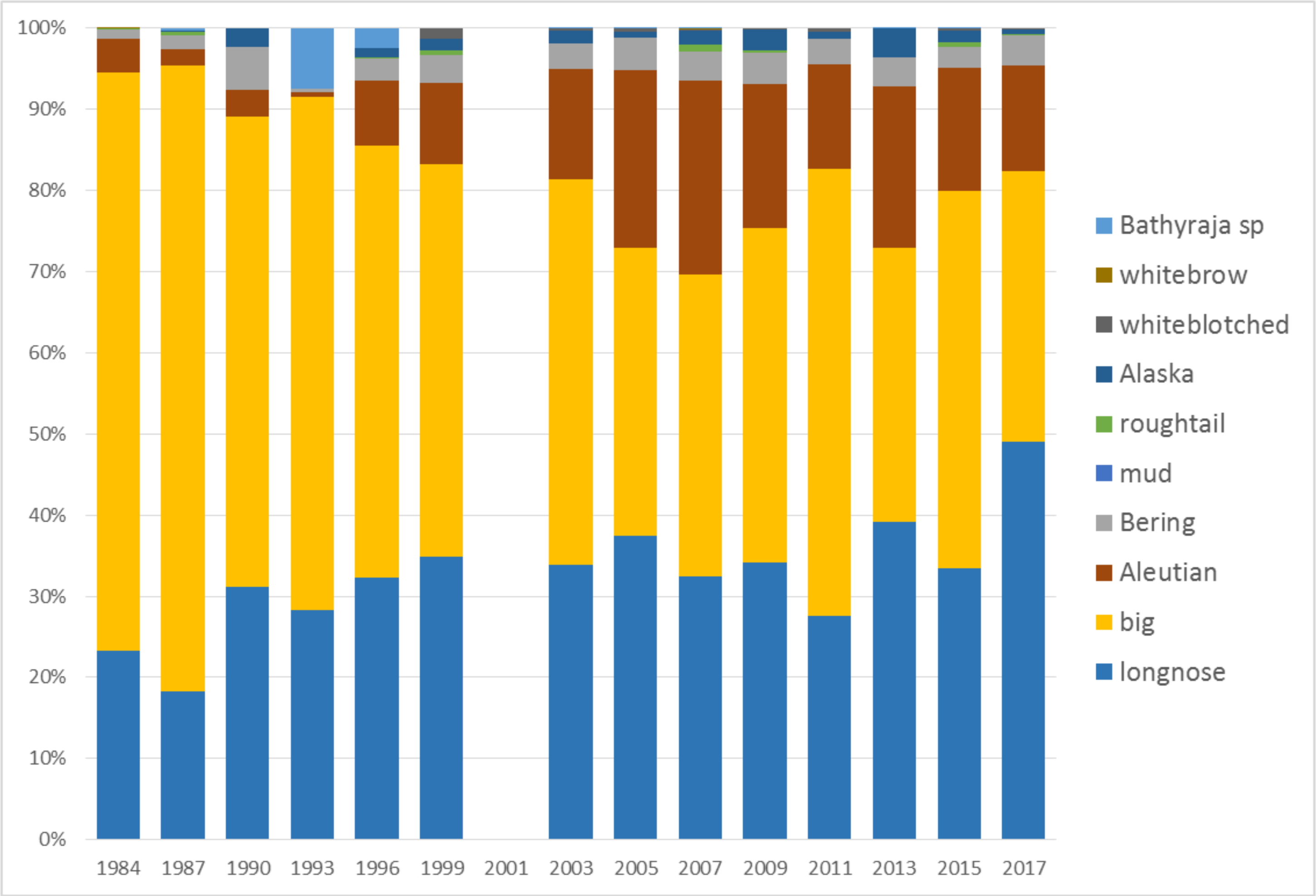
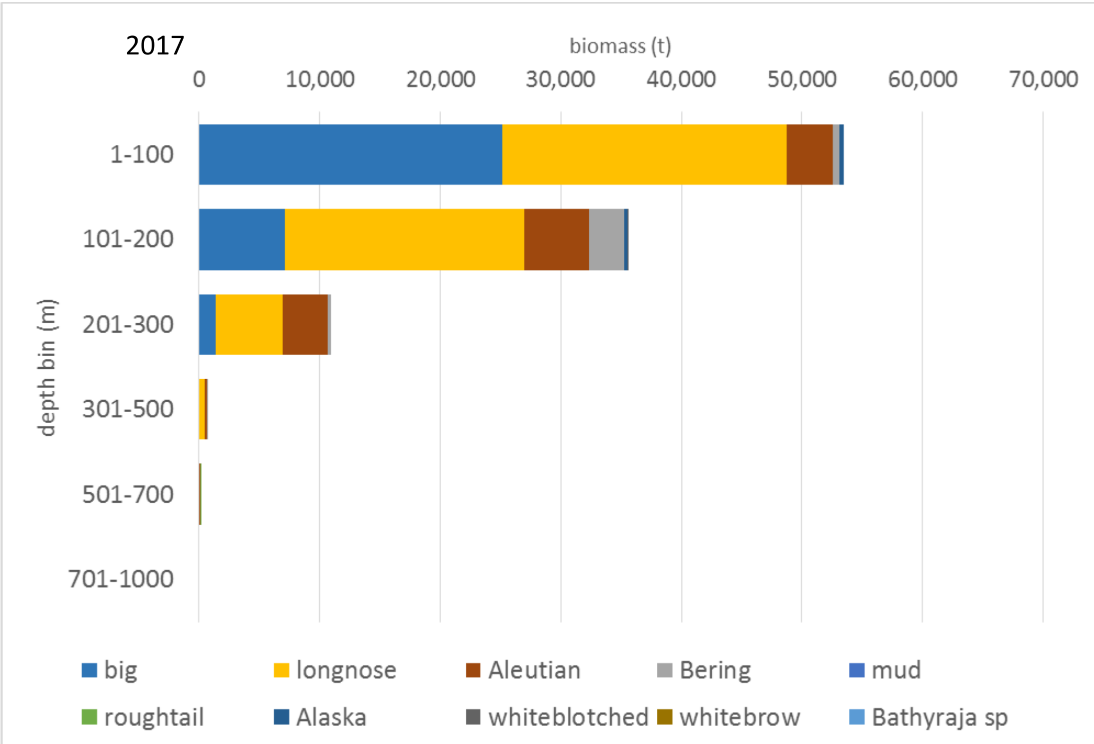


Figure 1. Gulfwide species composition of Gulf of Alaska (GOA) skates, 1984-2017. The 2001 survey did not sample in the eastern GOA.



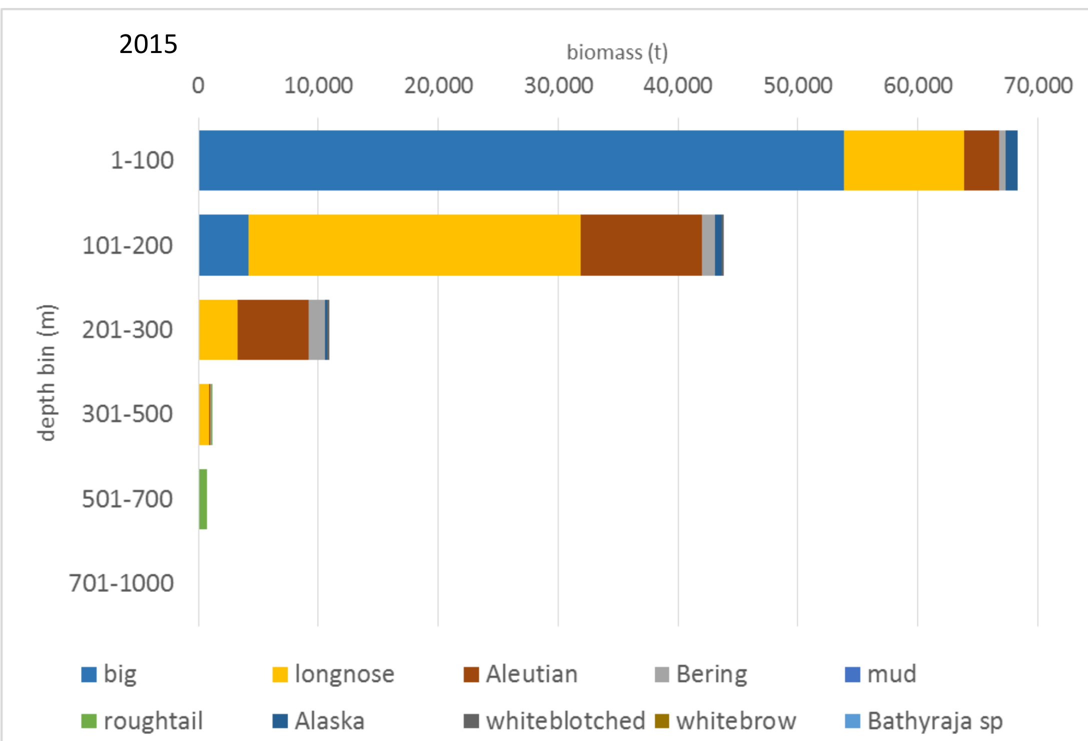
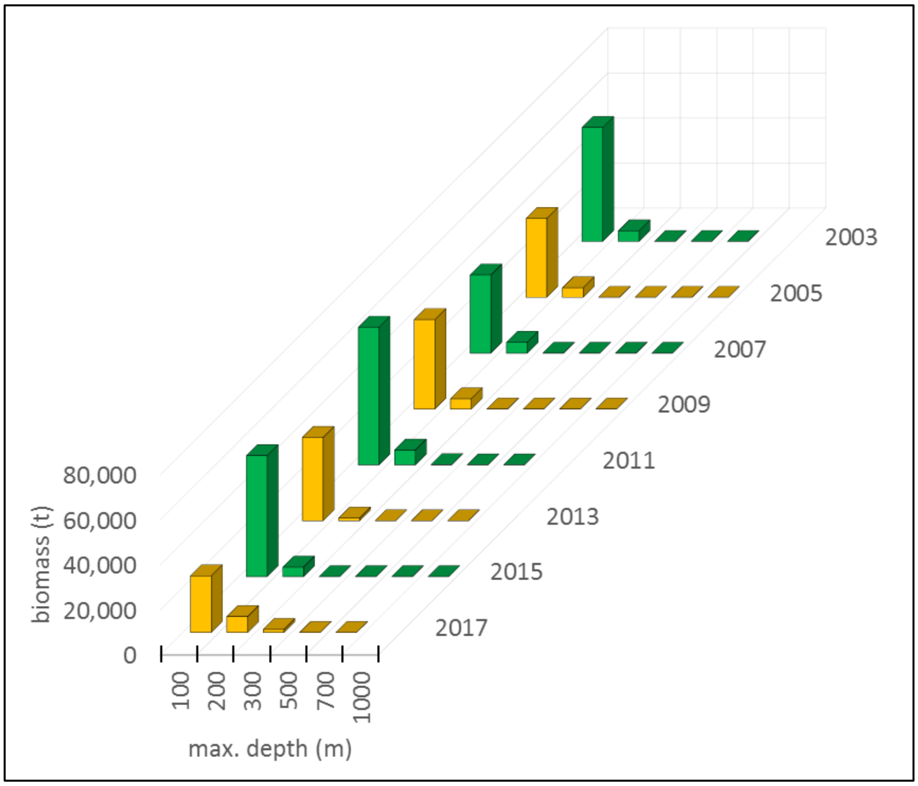


Figure 2. Biomass estimates (t) of skates at depth from the Gulf of Alaska bottom trawl survey. Data are from 2017 (top) and 2015 (bottom).



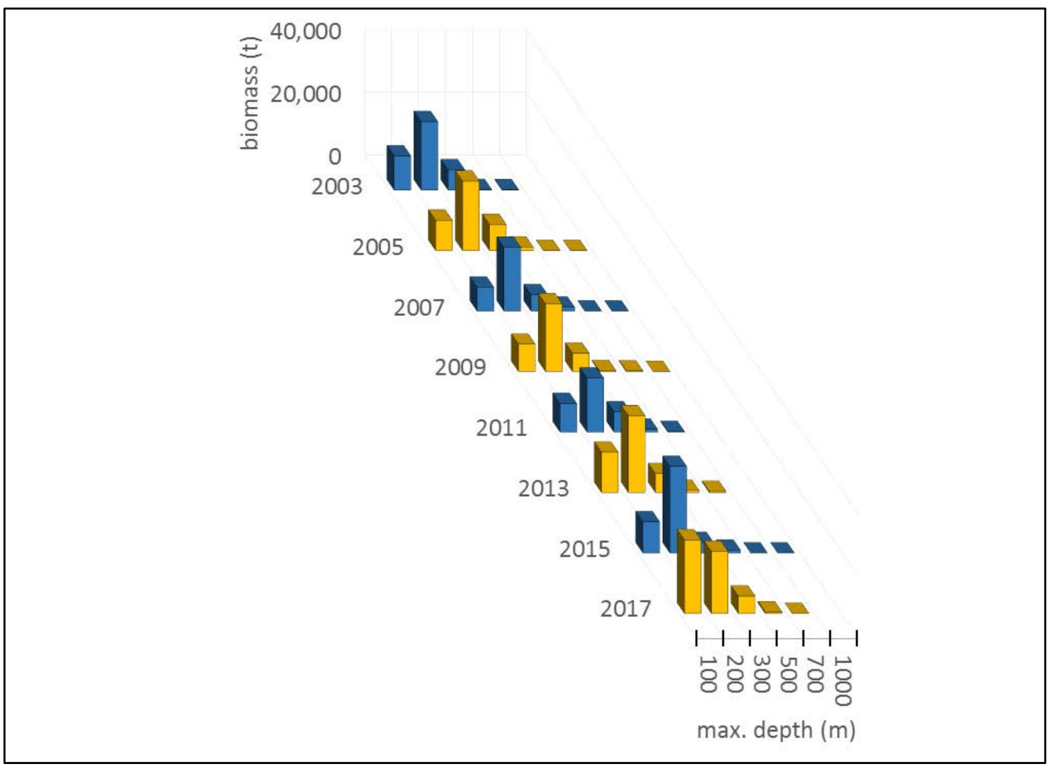


Figure 3. Multiyear depth distributions for big skates (top) and longnose skates (bottom) from the AFSC bottom trawl survey in the Gulf of Alaska.

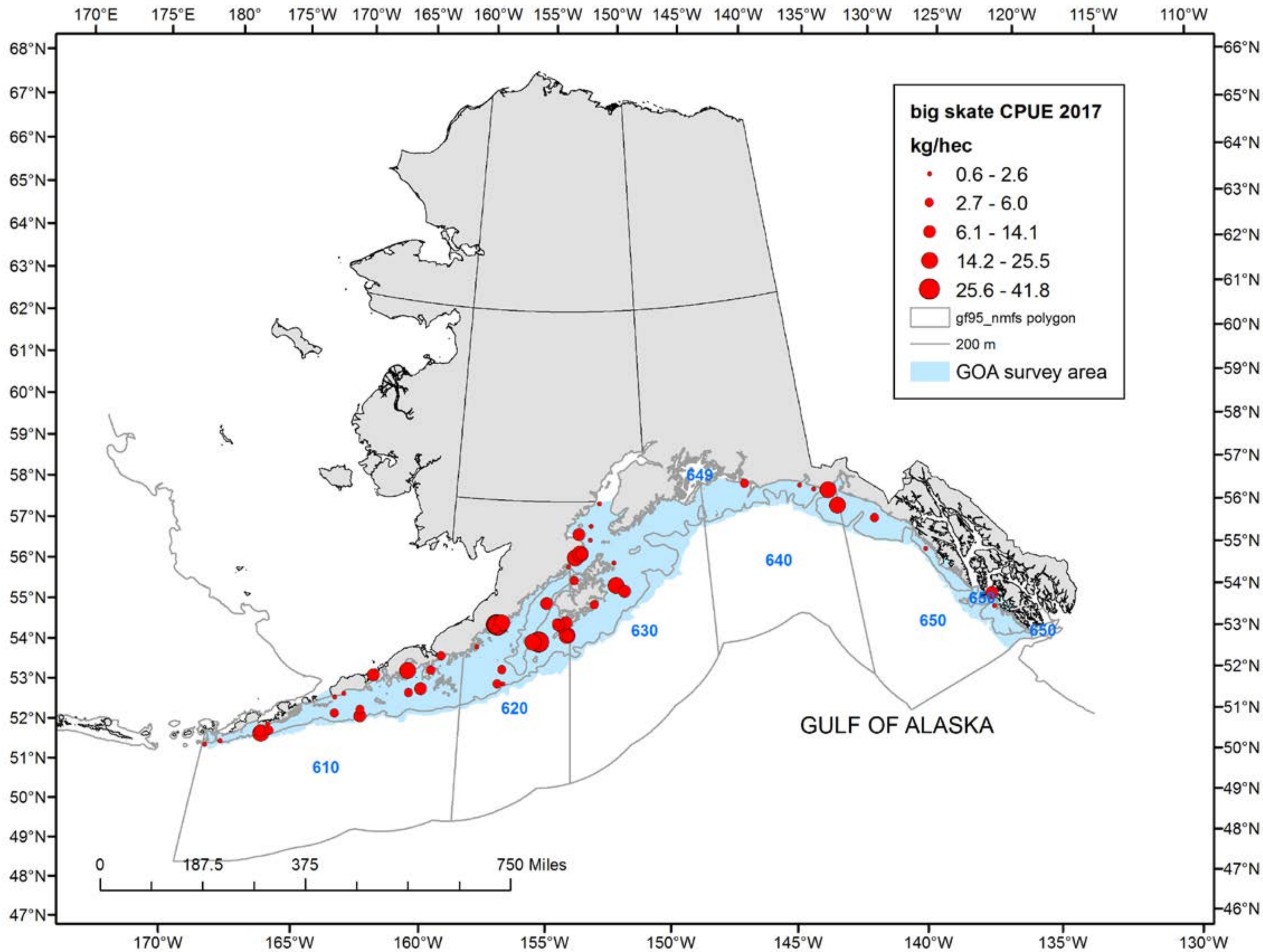


Figure 4. Catch-per-unit-effort of **big skates** in the AFSC Gulf of Alaska bottom trawl survey during 2017. Survey extent is shown by blue shading. Blue lettering indicates NMFS statistical area; GOA regulatory areas are western GOA (area 610), central GOA (areas 620 & 630), and eastern GOA (areas 640-659).

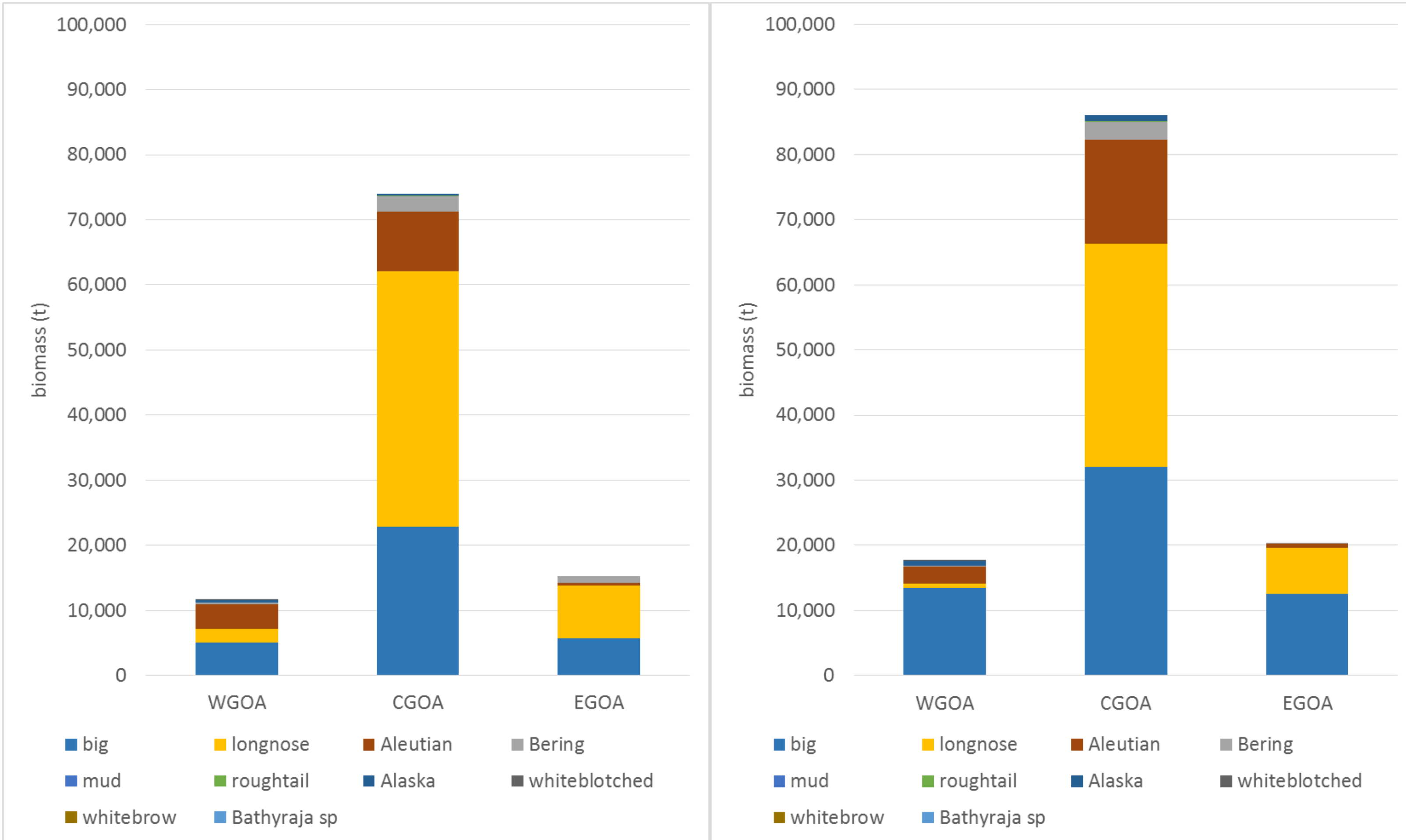


Figure 5. Species composition of skates in the Gulf of Alaska (GOA) bottom trawl survey, by regulatory area, in 2017 (left) and 2015 (right). WGOA= western GOA, CGOA = central GOA, EGOA = eastern GOA.

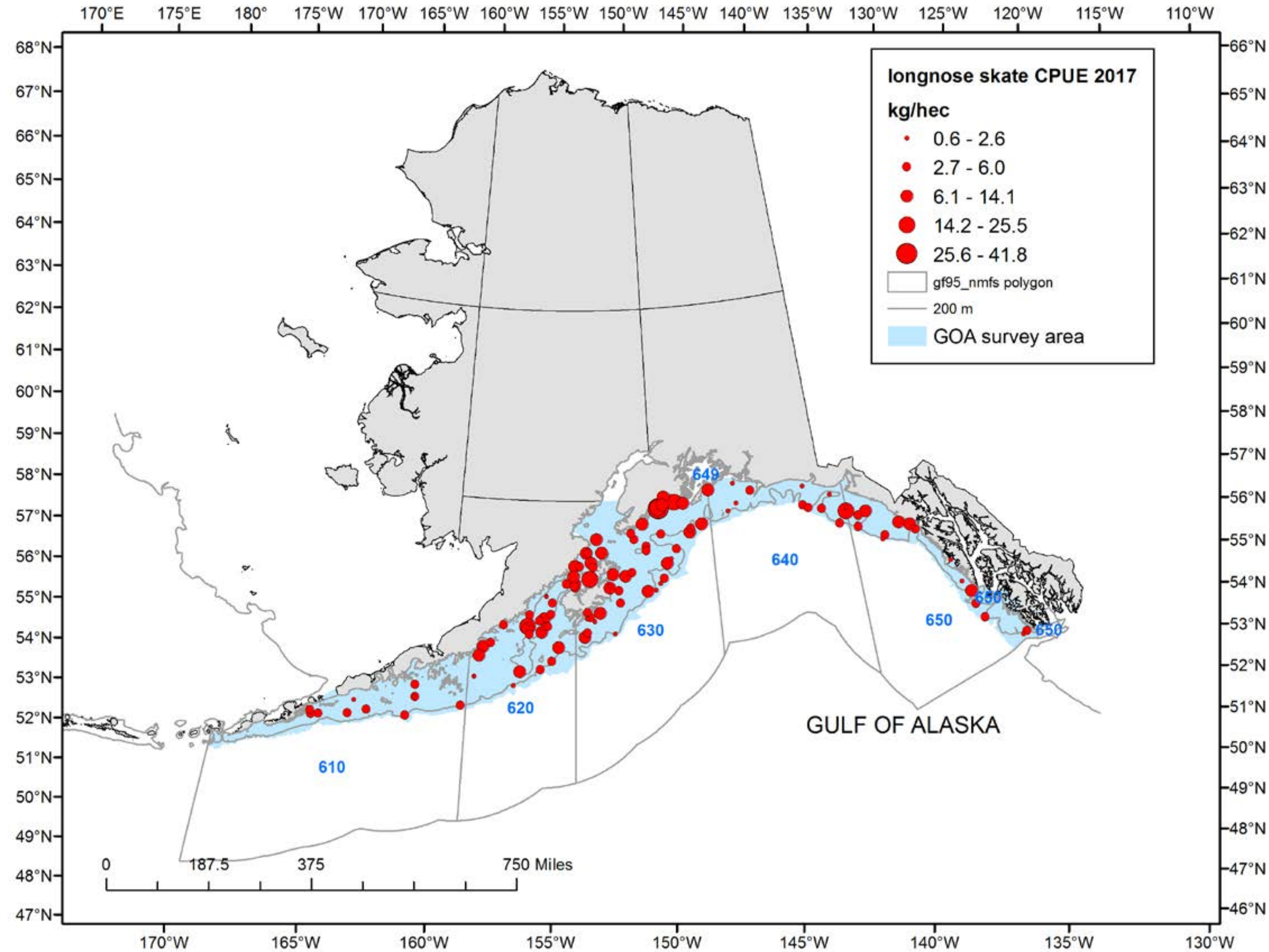


Figure 6. Catch-per-unit-effort of **longnose** skates in the AFSC Gulf of Alaska (GOA) bottom trawl survey during 2017. Survey extent is shown by blue shading. Blue lettering indicates NMFS statistical area; GOA regulatory areas are western GOA (area 610), central GOA (areas 620 & 630), and eastern GOA (areas 640-659).

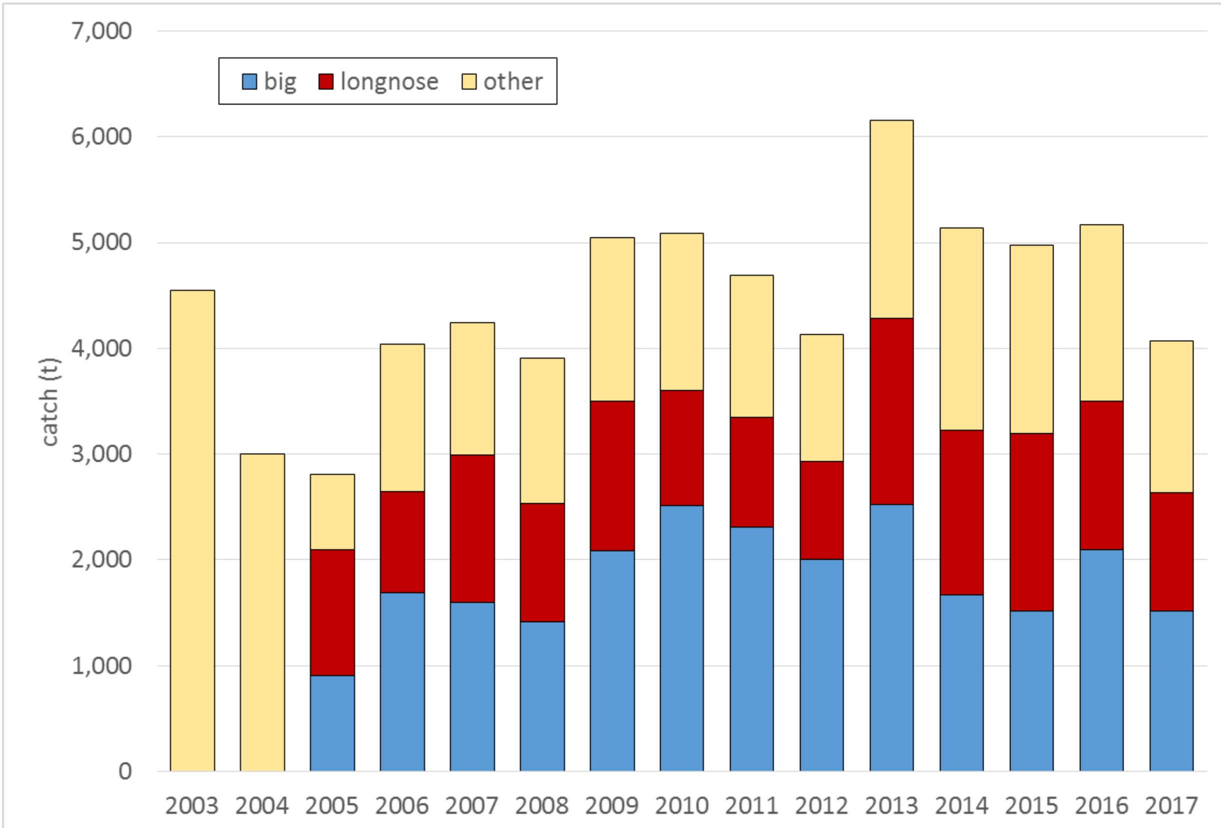


Figure 7. Catch (t) of the three main skate groups in the Gulf of Alaska, 2003-2017. Data are from the AK Regional Office. The 2017 data are incomplete; retrieved on October 31, 2017.

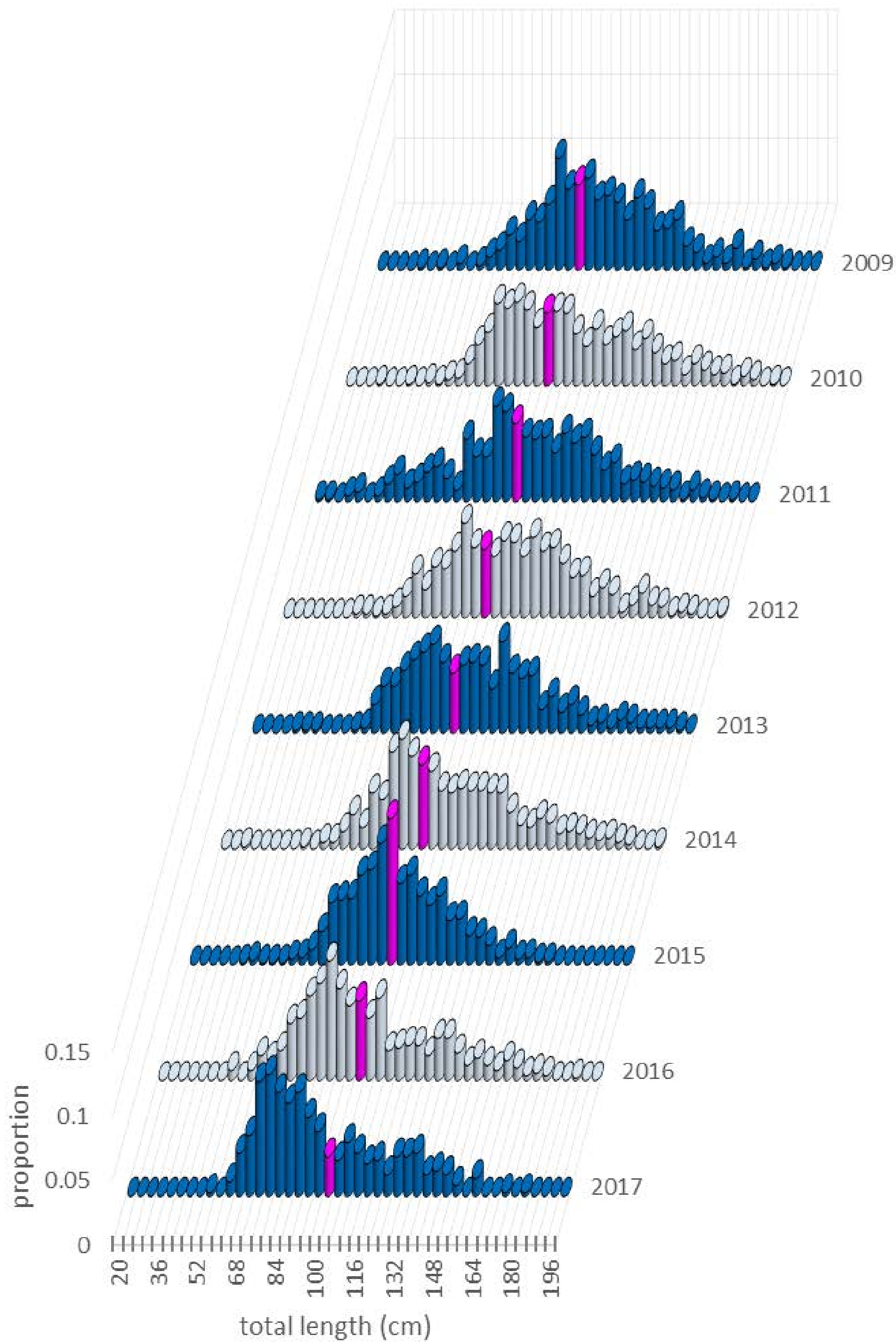


Figure 8. Length compositions of fishery catches (trawl and longline combined) for **big skates** in the Gulf of Alaska, 2009-2017. Data are in 4-cm length bins; fuchsia column indicates the 100-103 cm length bin in each dataset. The 2017 data are incomplete; retrieved on October 30, 2017.

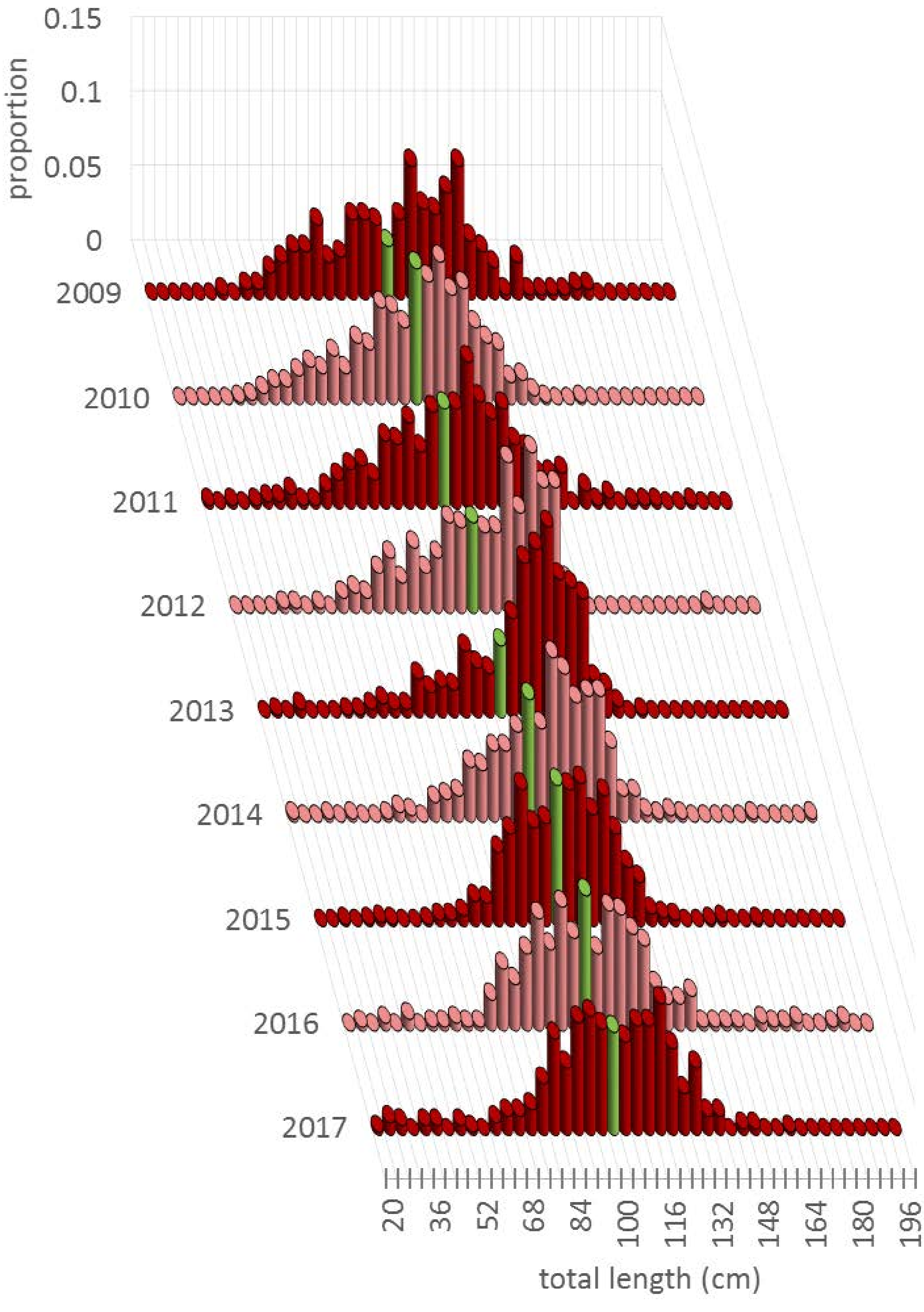


Figure 9. Length compositions of fishery catches (trawl and longline combined) for longnose skates in the Gulf of Alaska, 2009-2017. Data are in 4-cm length bins; green column indicates the 100-103 cm length bin in each dataset. The 2017 data are incomplete; retrieved on October 30, 2017.

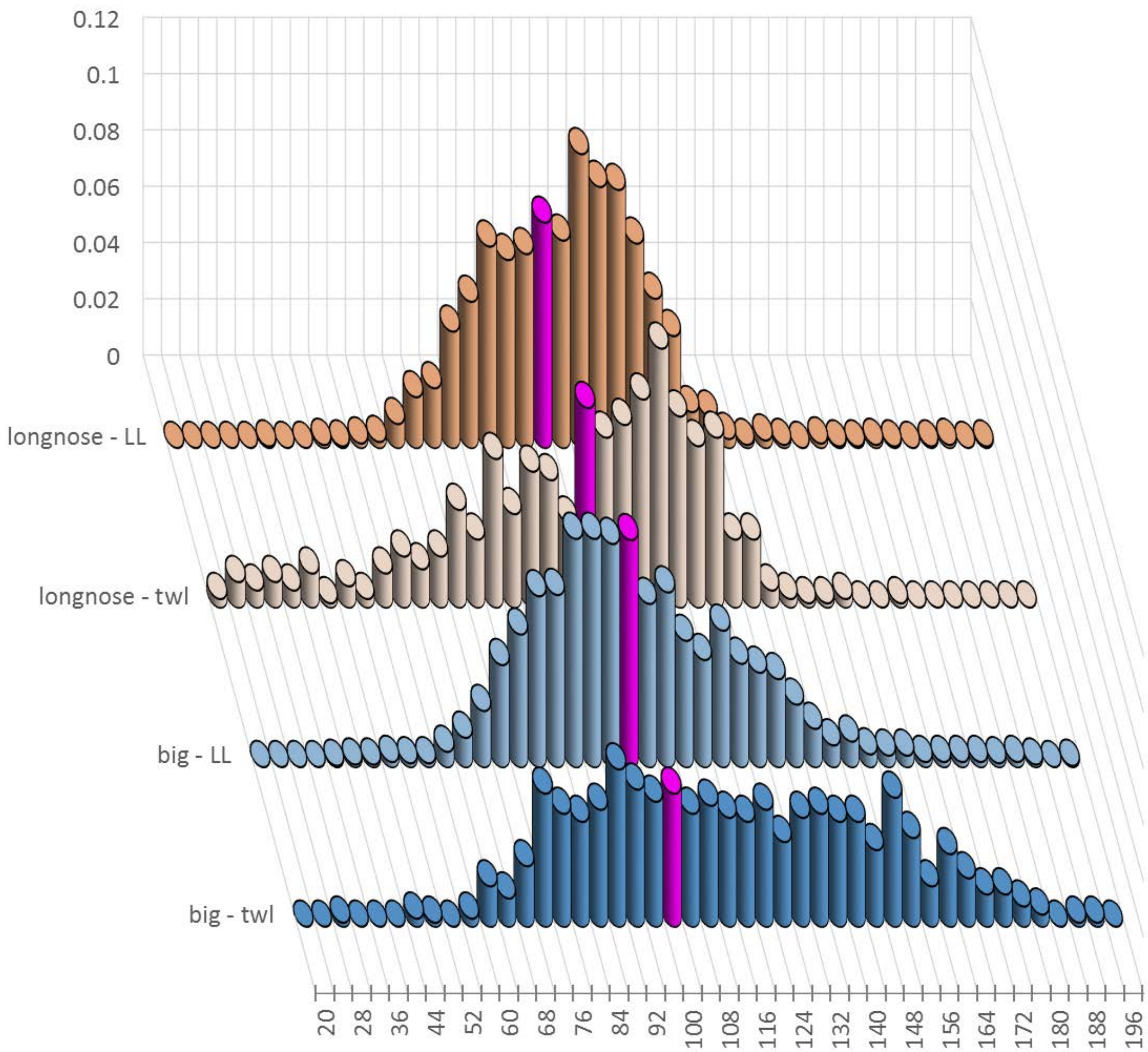


Figure 10. Comparison of trawl and longline fishery length compositions for big and longnose skates in the Gulf of Alaska, aggregated over the years 2013-2017. Data are in 4-cm length bins; fuchsia column indicates the 100-103 cm length bin in each dataset.

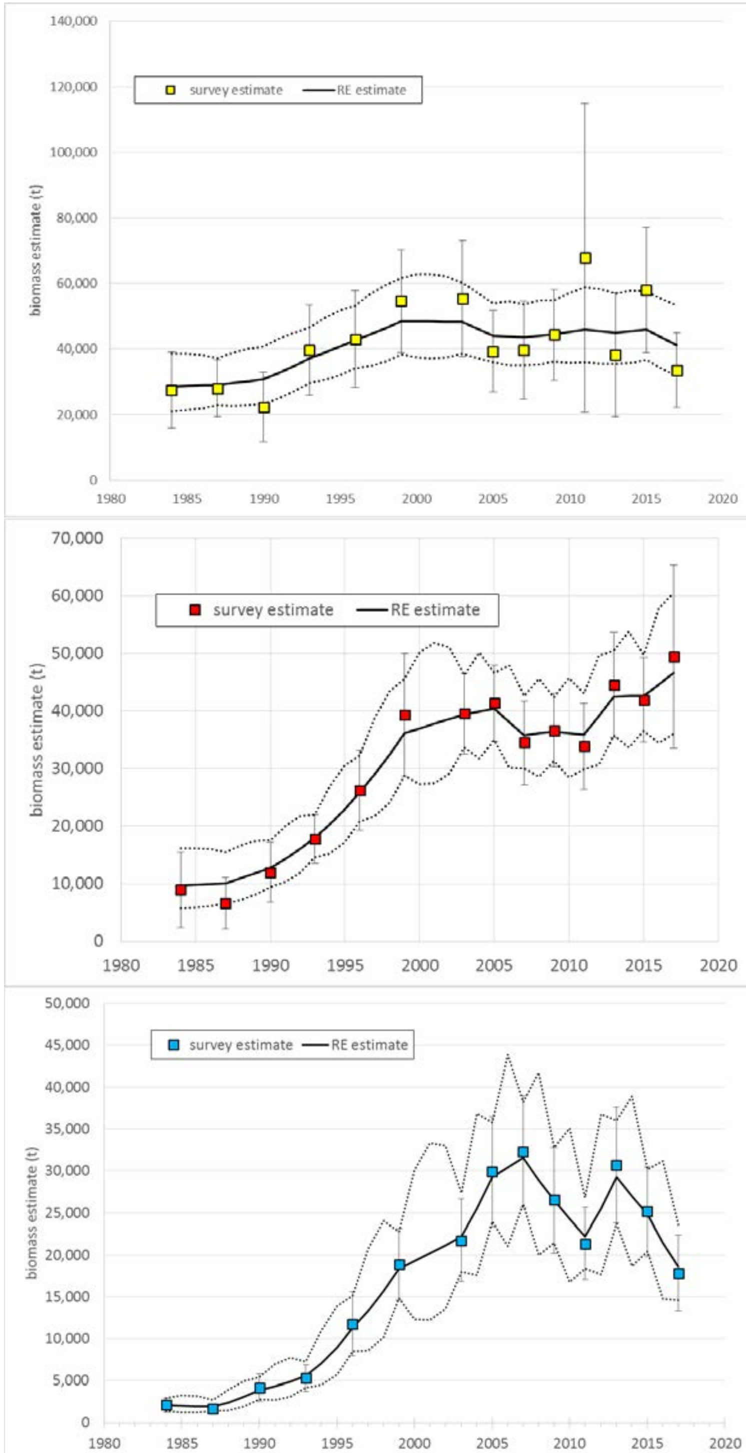


Figure 11. Biomass estimates (t) for big skates (top), longnose skates (middle), and Other Skates (bottom), 1984-2017, from the AFSC bottom trawl survey in the Gulf of Alaska. Filled symbols indicate survey biomass estimates with 95% confidence interval (CI) shown as error bars. Black line indicates biomass estimate from the random-effects model; dashed black lines indicate 95% CI. Note that vertical scales differ among the plots.

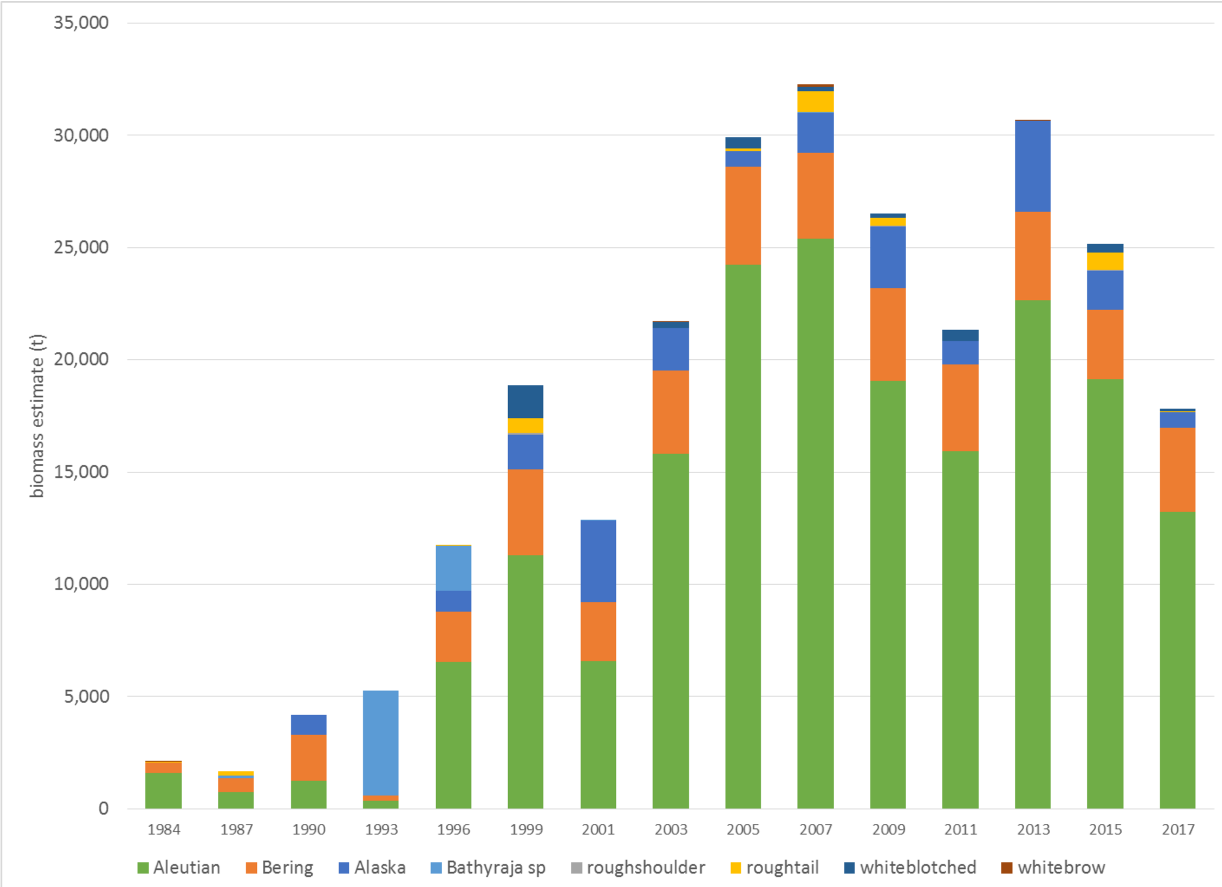


Figure 12. NMFS Gulf of Alaska (GOA) bottom trawl survey biomass trends for *Bathyraja* skates (i.e. Other Skates) 1984-2017. The 2001 survey did not sample in the eastern GOA. For information regarding the uncertainty of the Other Skates biomass estimate see Figure 11.

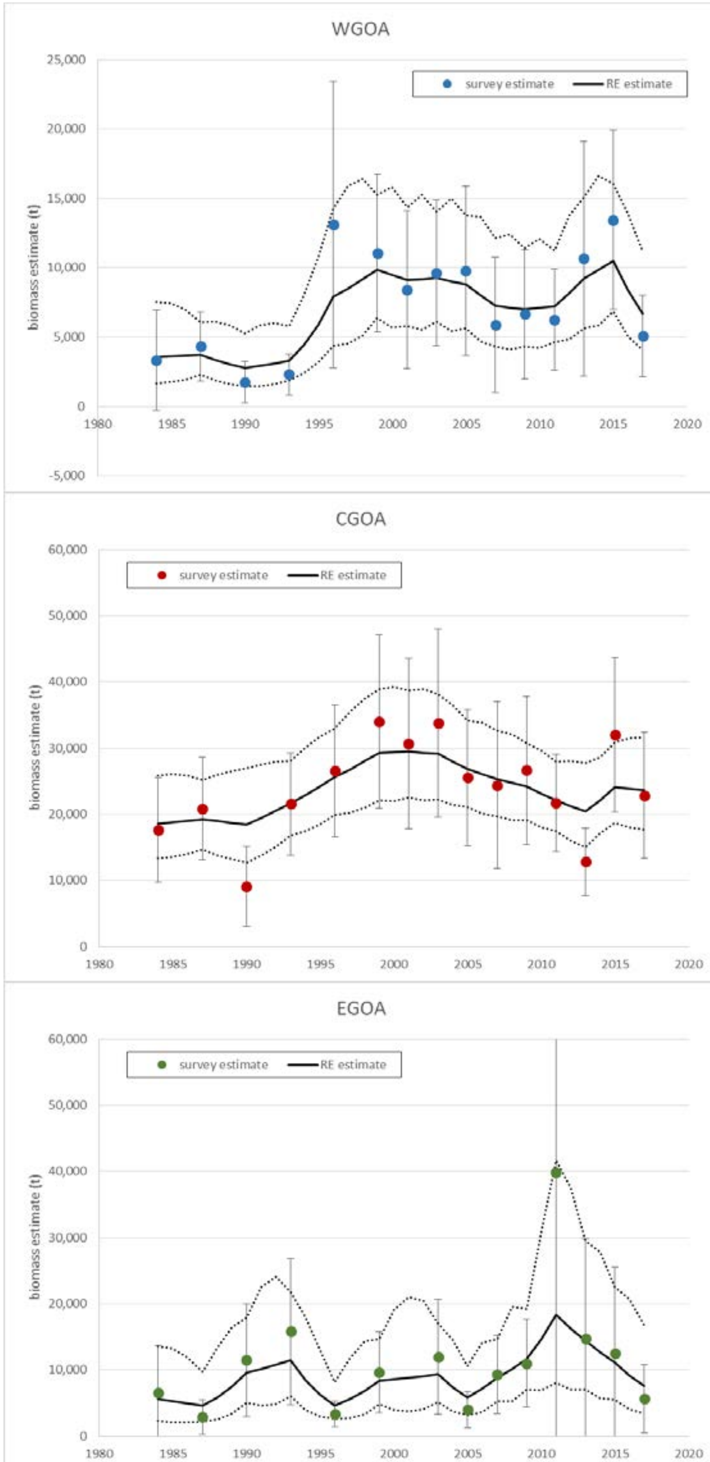


Figure 13. Biomass estimates (t) for **big skates** in 3 Gulf of Alaska (GOA) regions from the GOA trawl survey (colored dots) and predictions from a random-effects model based on those estimates (black line) for other skates, 1984-2017. 95% confidence intervals are indicated by error bars and dotted black lines for the survey and model estimates, respectively. Note that vertical scales differ among the plots.

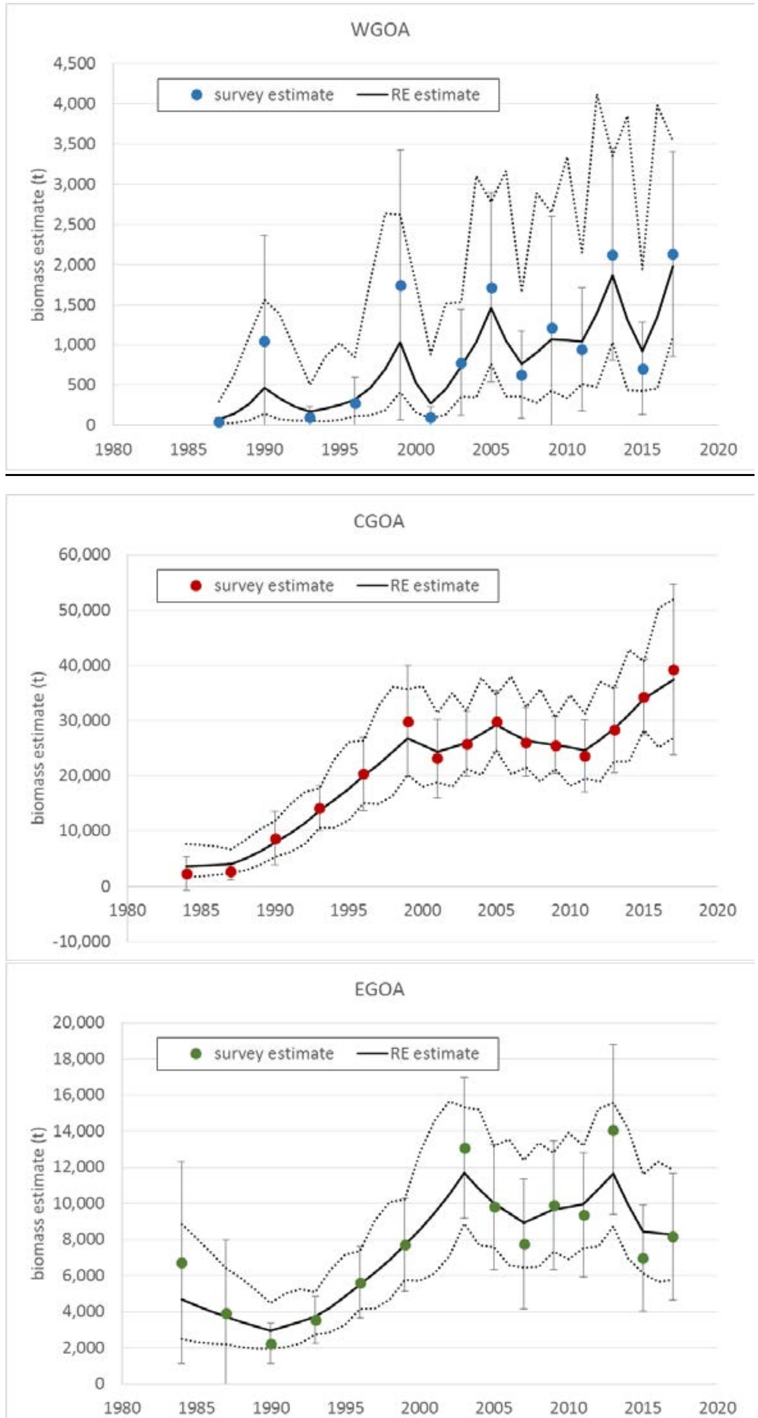


Figure 14. Biomass estimates (t) for **longnose skates** in 3 Gulf of Alaska (GOA) regions from the GOA trawl survey (colored dots) and predictions from a random-effects model based on those estimates (black line) for other skates, 1984-2017. 95% confidence intervals are indicated by error bars and dotted black lines for the survey and model estimates, respectively. Note that vertical scales differ among the plots.

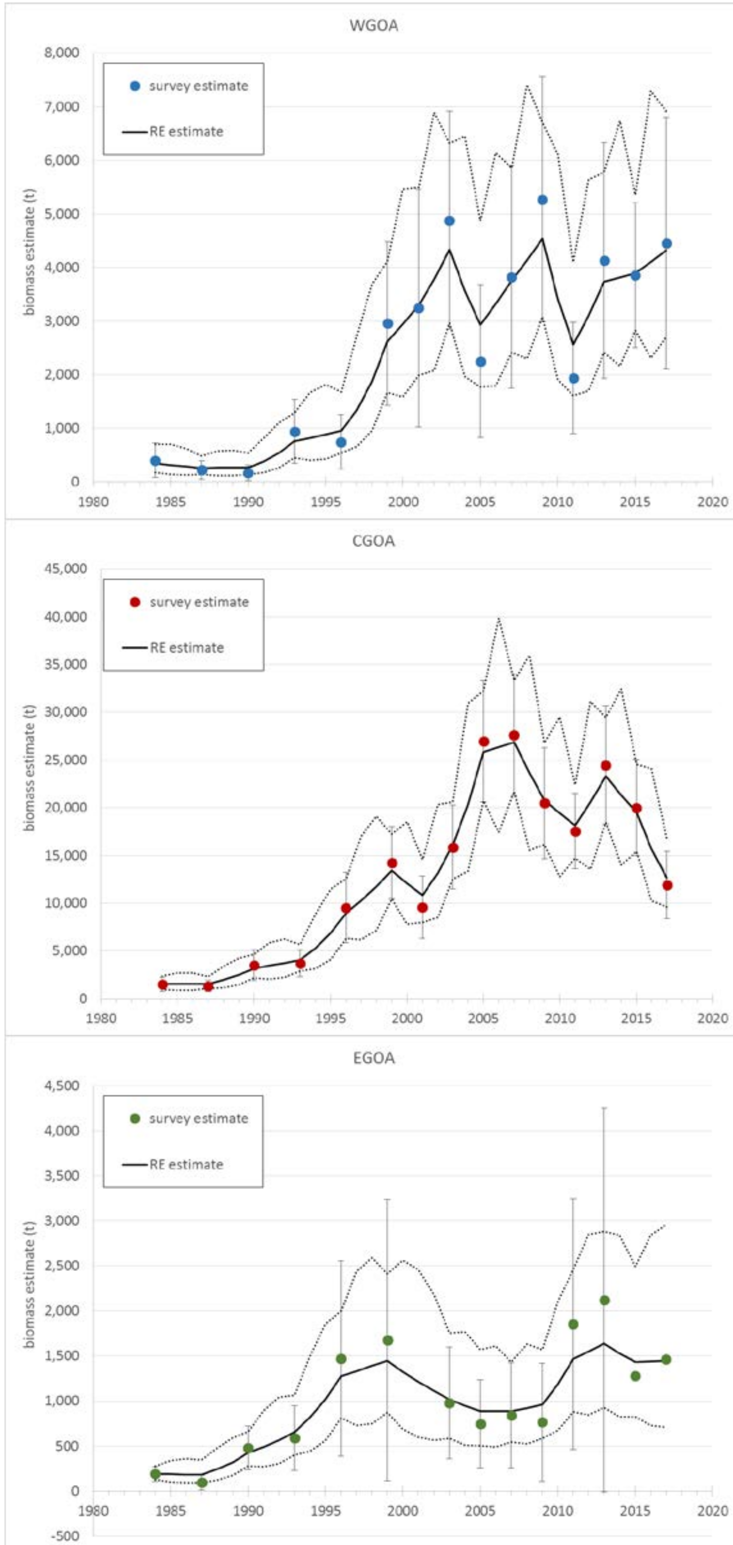


Figure 15. Biomass estimates (t) for **other skates** in 3 Gulf of Alaska (GOA) regions from the GOA trawl survey (colored dots) and predictions from a random-effects model based on those estimates (black line) for other skates, 1984-2017. 95% confidence intervals are indicated by error bars and dotted black lines for the survey and model estimates, respectively. Note that vertical scales differ among the plots.

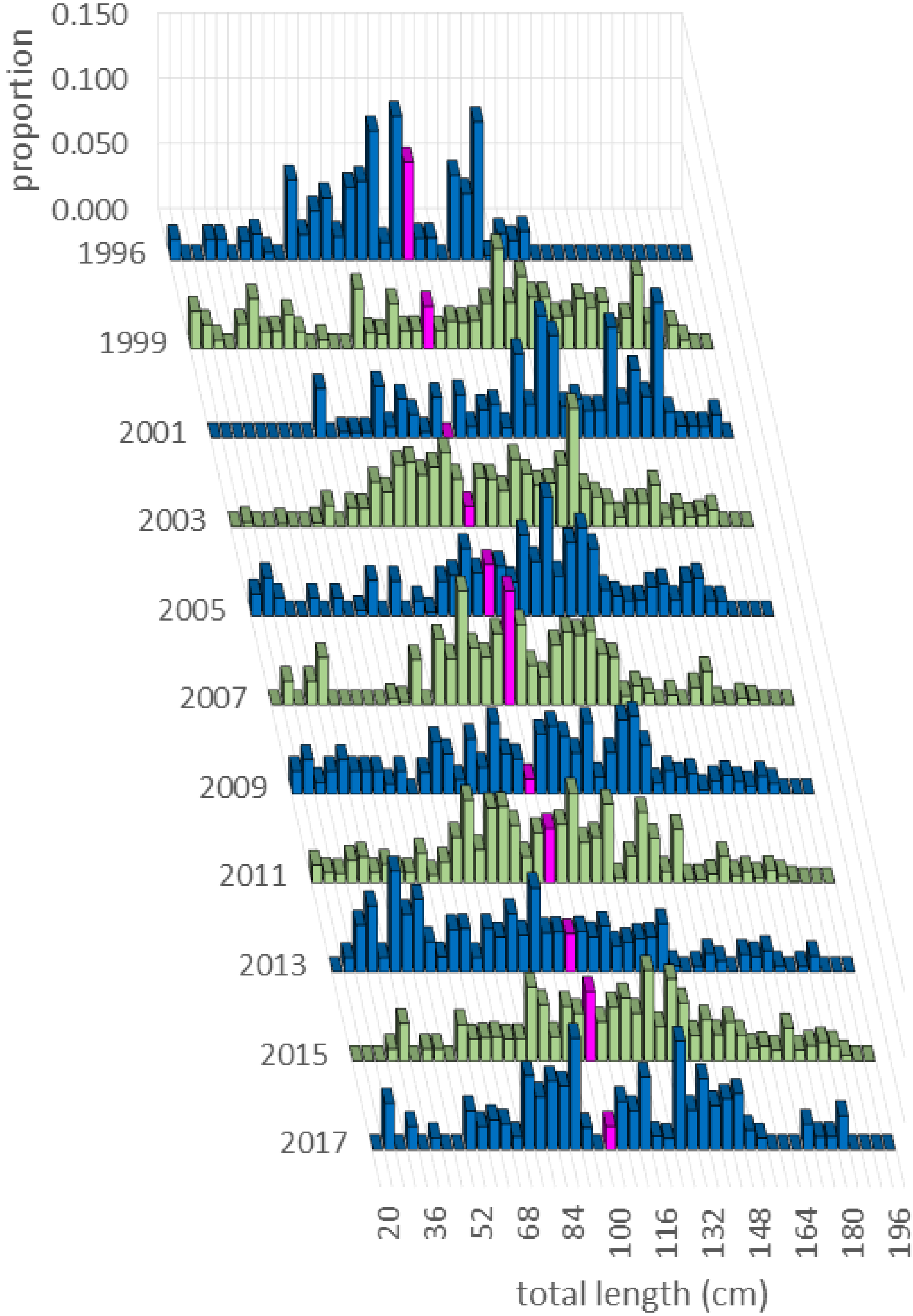


Figure 16. Length compositions of **big skates**, 1996-2017, from the AFSC bottom trawl survey in the Gulf of Alaska. Data are in 4-cm length bins; fuchsia column indicates the 100-103 cm length bin in each dataset.

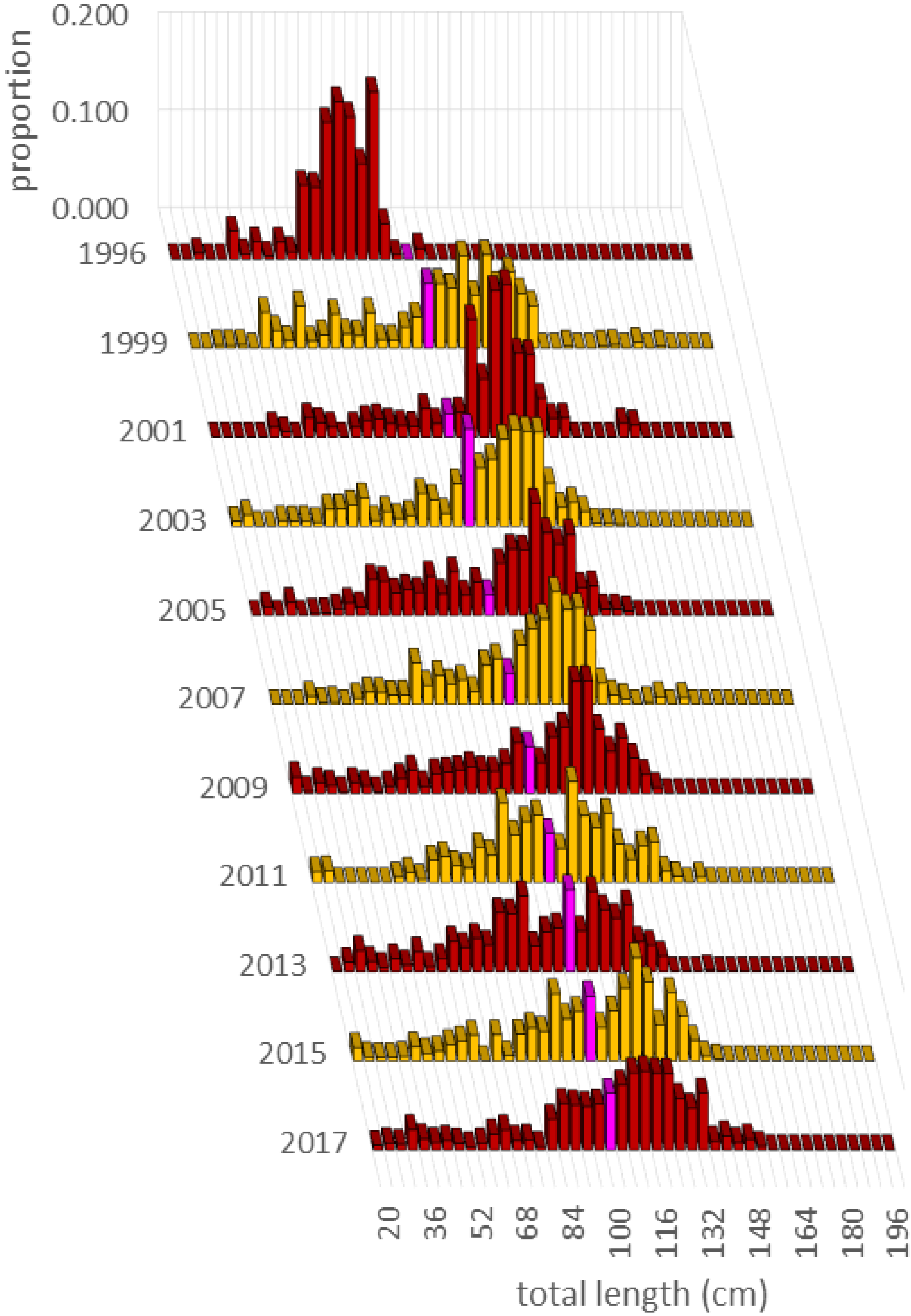


Figure 17. Length compositions of **longnose skates**, 1996-2017, from the AFSC bottom trawl survey in the Gulf of Alaska. Data are in 4-cm length bins; fuchsia column indicates the 100-103 cm length bin in each dataset.

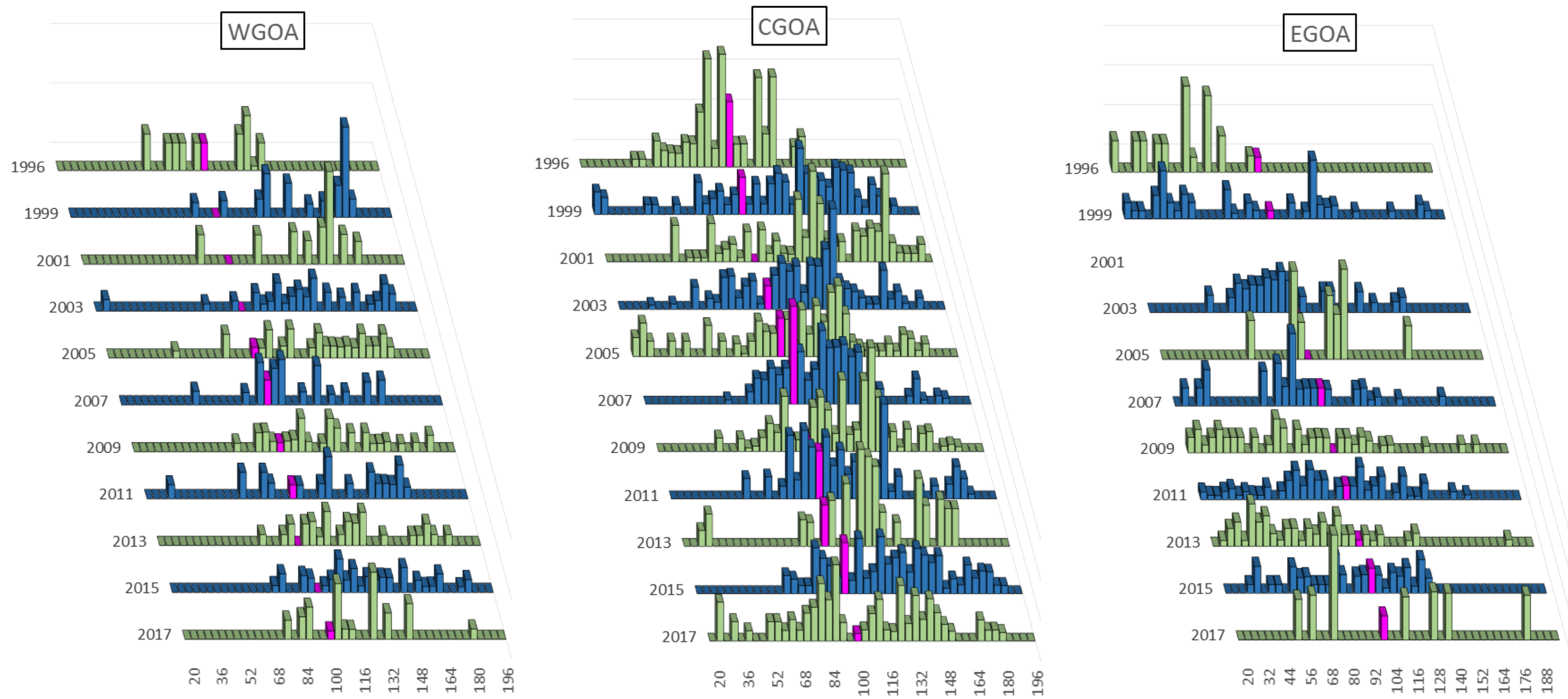


Figure 18. Length compositions of **big skates**, 1996-2017, from the AFSC bottom trawl survey in the Gulf of Alaska. Data are separated by regulatory area: WGOA = western GOA, CGOA = central GOA, EGOA = eastern GOA. Data are in 4-cm length bins; fuchsia column indicates the 100-103 cm length bin in each dataset.

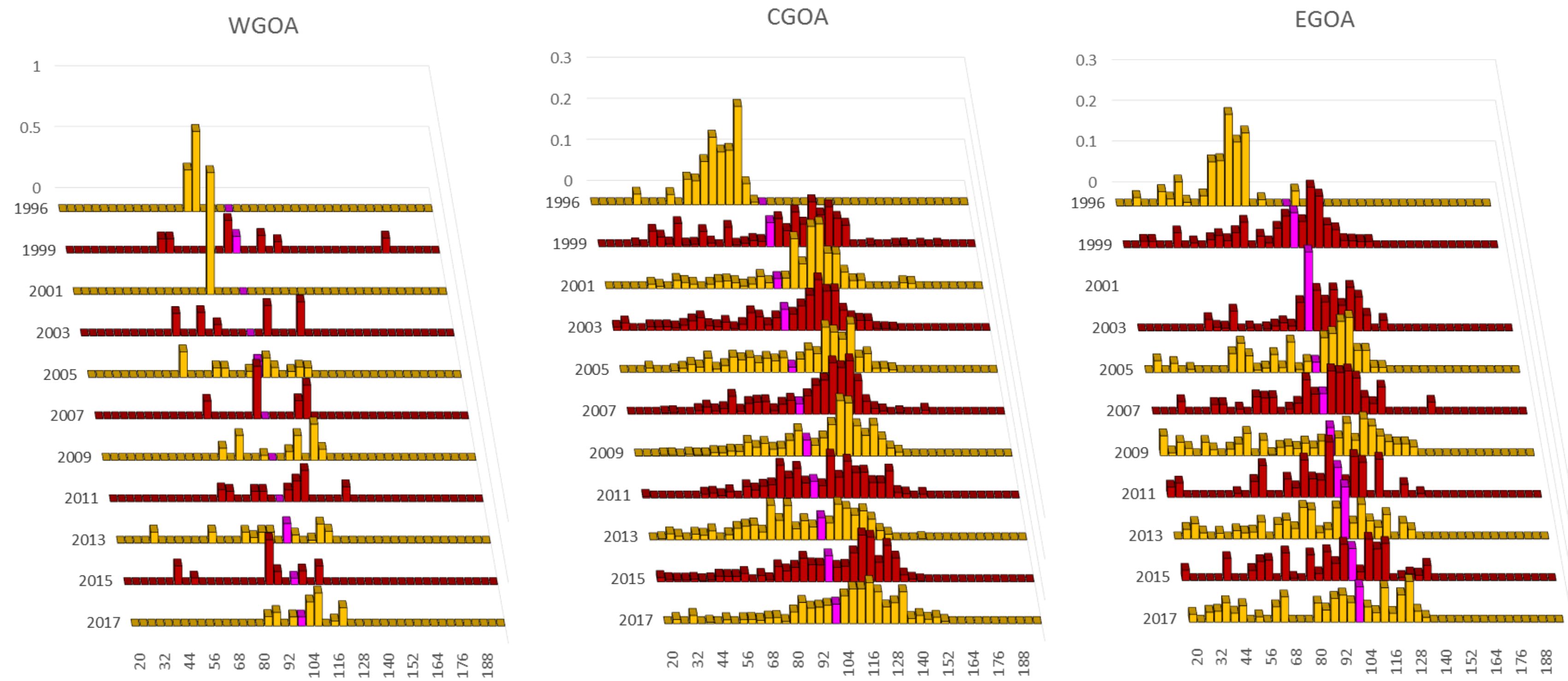


Figure 19. Length compositions of **longnose**, 1996-2017, from the AFSC bottom trawl survey in the Gulf of Alaska (GOA). Data are separated by regulatory area: WGOA = western GOA, CGOA = central GOA, EGOA = eastern GOA. Data are in 4-cm length bins; fuchsia column indicates the 100-103 cm length bin in each dataset.

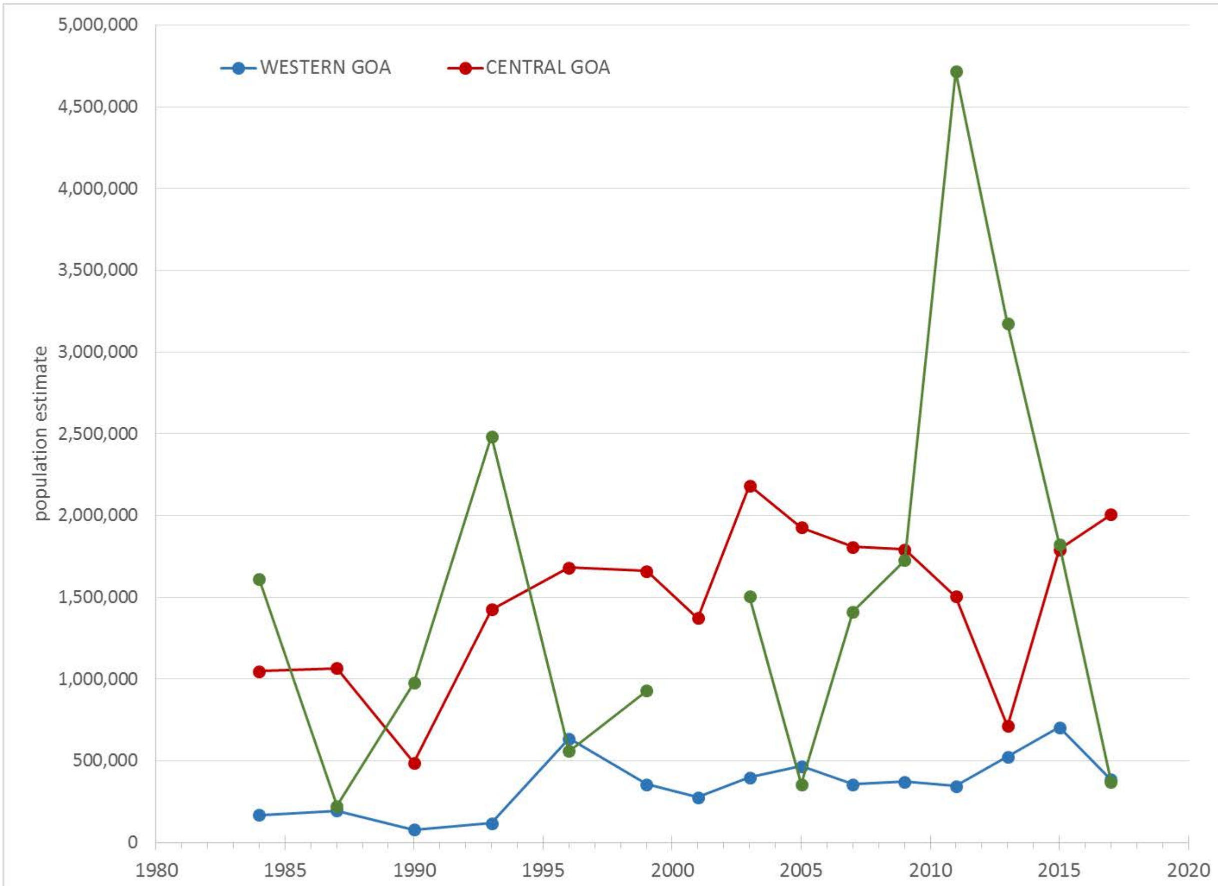


Figure 20. Estimated population size (numbers) for big skates in the Gulf of Alaska, 1984-2017, from the AFSC bottom trawl survey.

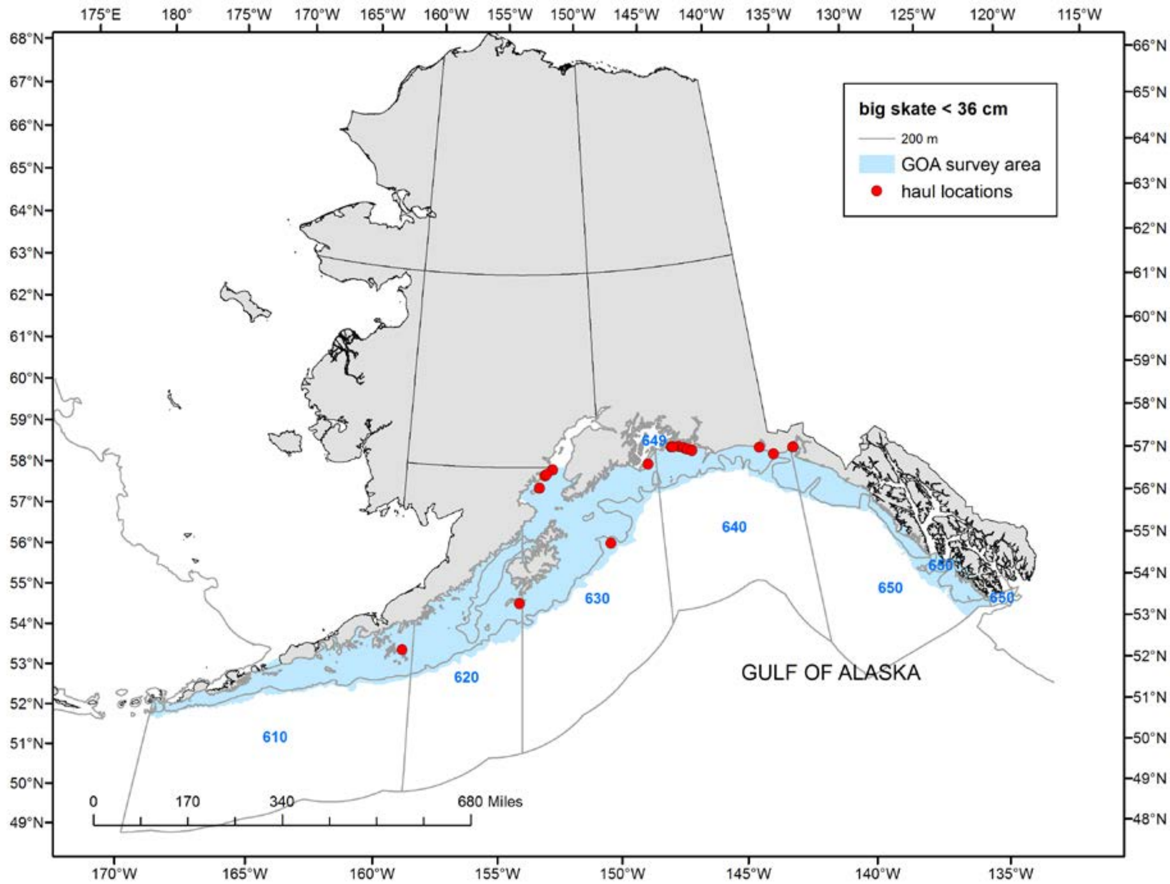


Figure 21. Locations of AFSC bottom trawl survey hauls containing small juvenile big skates (< 36 cm total length) in the Gulf of Alaska from 2003 to 2017.

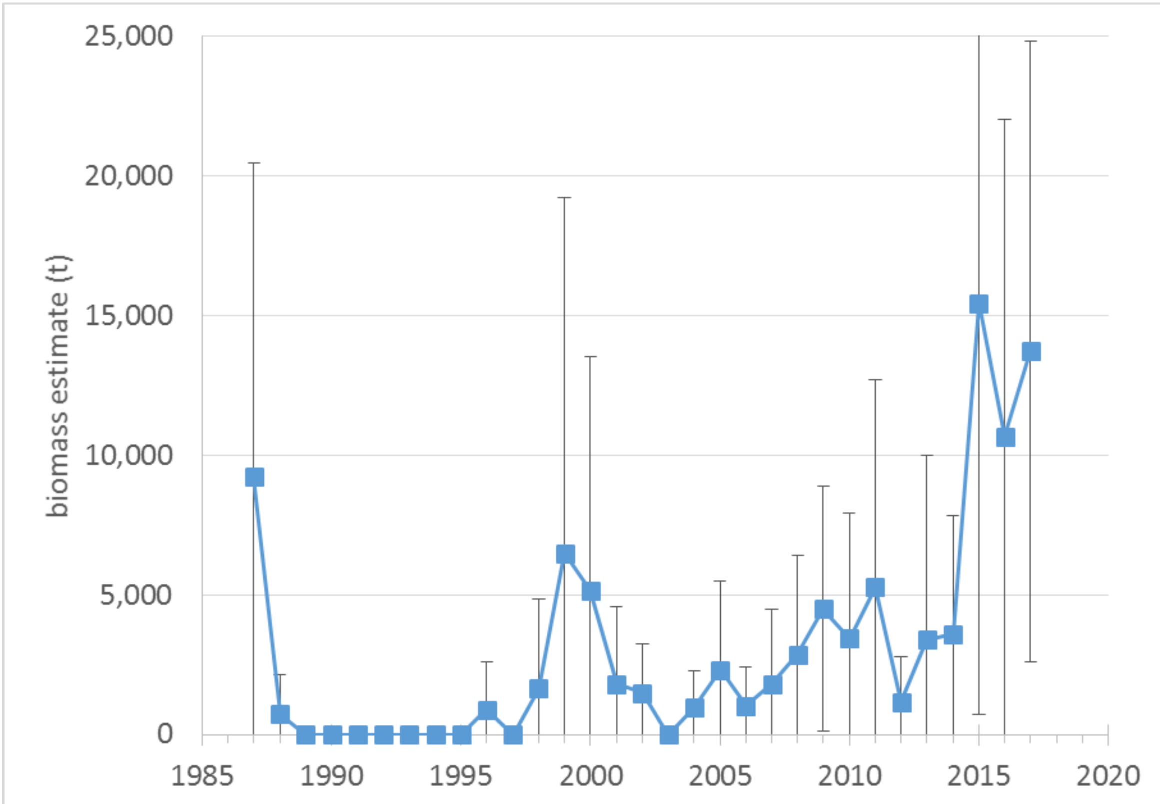


Figure 22. Estimated biomass (t) of big skates on the eastern Bering Sea shelf, from the AFSC bottom trawl survey. Error bars indicate 95% confidence interval.

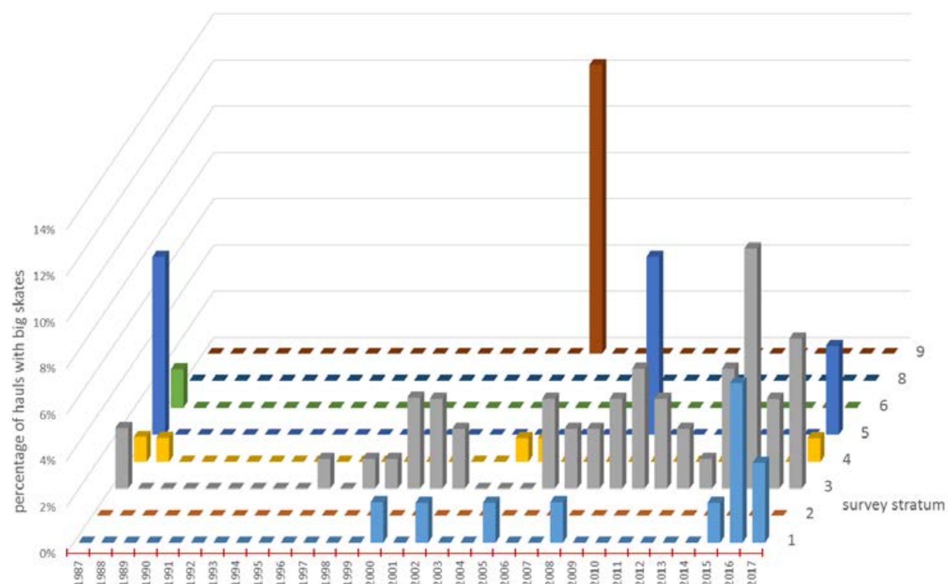


Figure 23. Occurrence of big skates in AFSC bottom trawl survey hauls on the eastern Bering Sea shelf, by survey stratum. Strata 1 & 3 are the southernmost strata in the survey area.

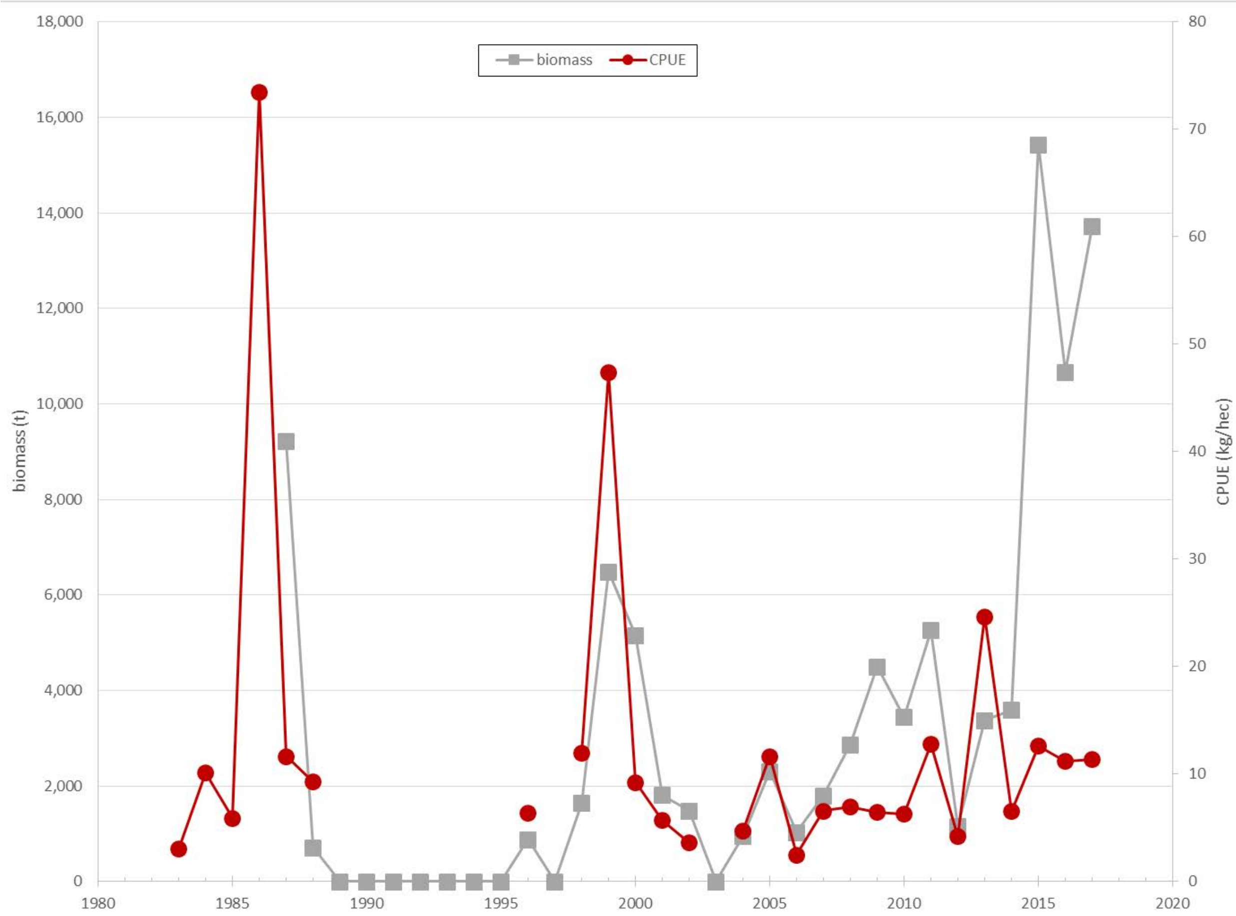


Figure 24. Biomass estimate (t) and catch-per-unit-effort (CPUE; kg/hec) of big skates in the eastern Bering Sea shelf survey.

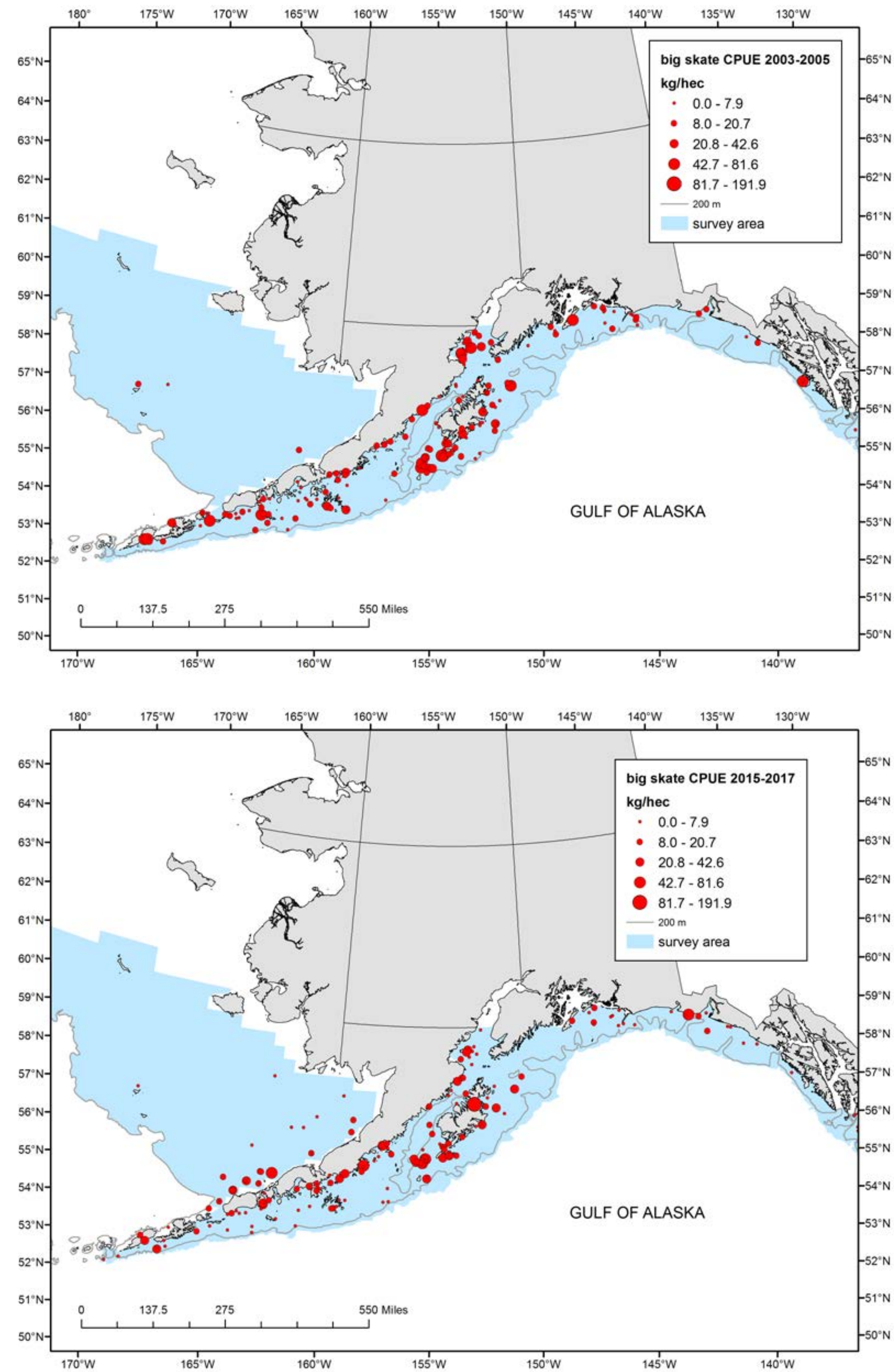


Figure 25. Trawl survey catch-per-unit-effort (CPUE; kg/hec) of big skates during periods of low (2003-2005, top panel) and high (2015-2017) frequency of occurrence.

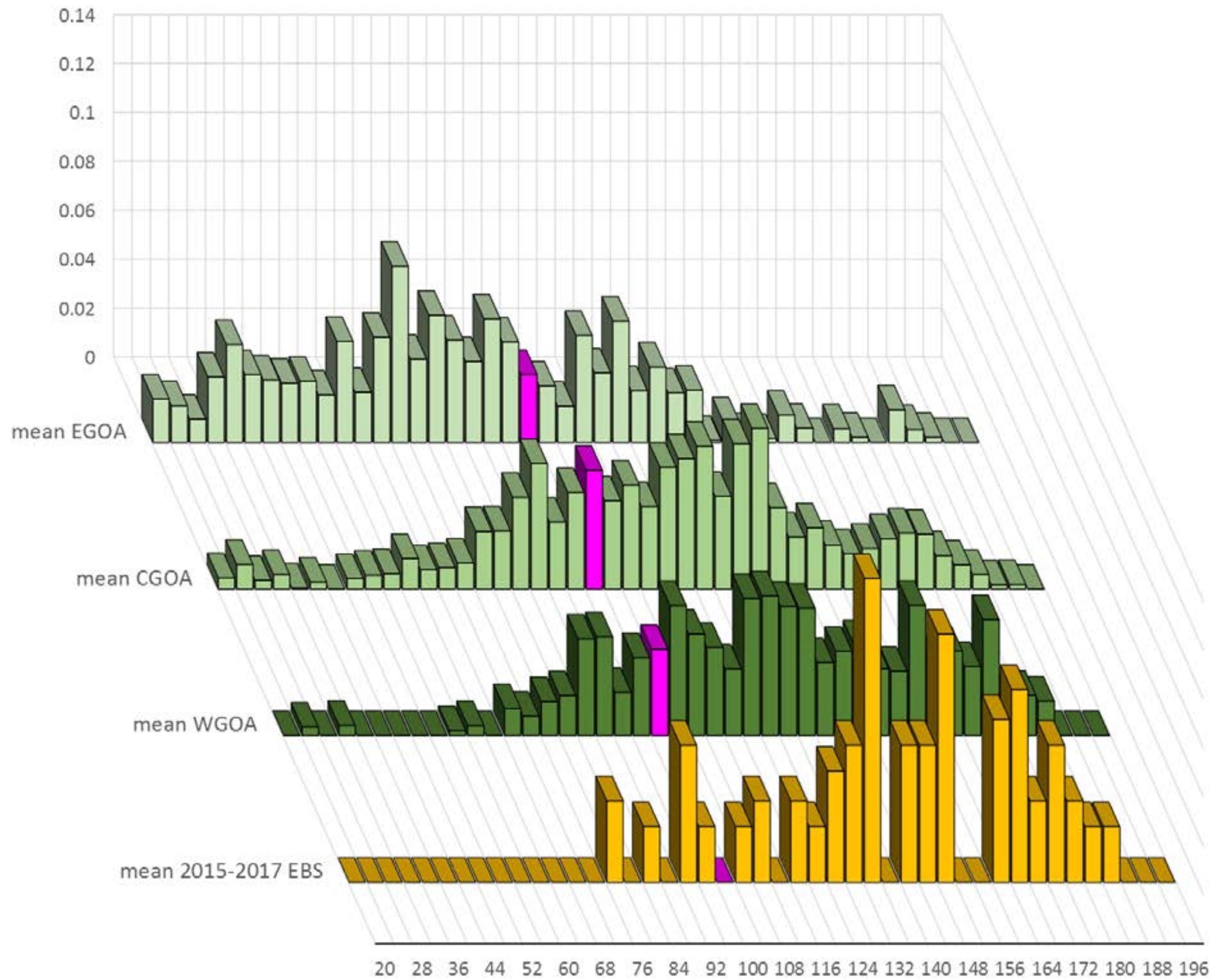


Figure 26. Mean trawl-survey length compositions of big skates in three areas of the Gulf of Alaska (2003-2017) and the length composition of big skates in the eastern Bering Sea shelf trawl survey during 2015-2017. Fuchsia color indicates the 100-103 cm length bin and is for reference purposes only.

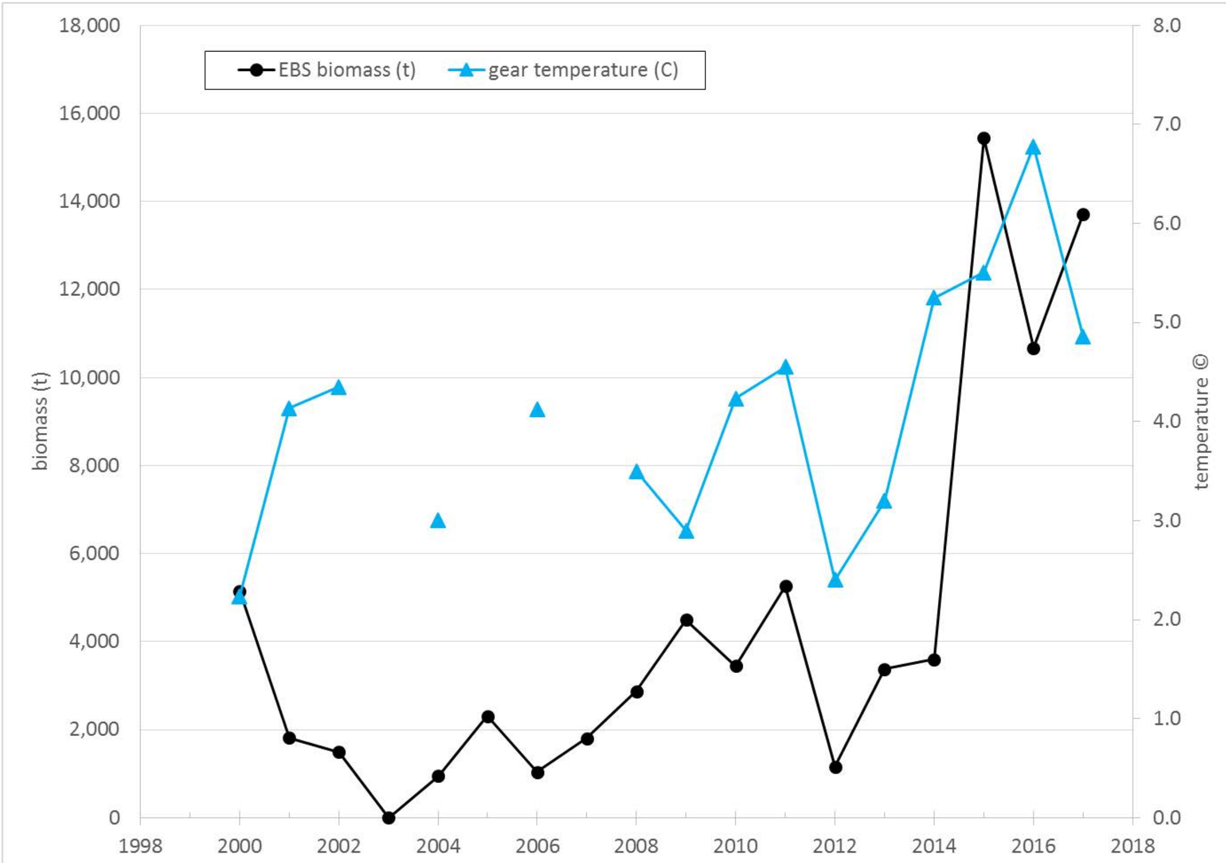


Figure 27. Trawl-survey biomass estimates (t) from the EBS shelf survey and mean annual bottom temperature (°C) in EBS shelf survey hauls containing big skates.

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	Shumagins 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
2015	628	2,931	32,865	8,136			0			164	44,724
2016	239		28,183	10,637			1			473	39,533

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	Shumagins 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
2015	11,175		2,525	73,371	6,853					256	94,180
2016	10,832			36,667	5,016			12		105	52,632

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
2015	261		2,021	15,896	2,578							20,756
2016	108			9,909	1,713			59		4		11,793