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

Olav A. Ormseth
NMFS Alaska Fisheries Science Center, Seattle WA

Executive Summary

The Gulf of Alaska (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. Normally, only an executive summary is prepared in even years; because the federal shutdown in 2013 resulted in a truncated stock assessment process, a full assessment was prepared in 2014.

Summary of Changes in Assessment Inputs

Changes in the input data:

1) Fully updated groundfish fishery catch data (2014 catch data as of October 8, 2014).
2) Biomass estimates and length composition data from the 2013 GOA bottom trawl survey.
3) Fishery length composition data through 2013.
4) An appendix containing information on catches of skates not accounted for in the Alaska Regional Office's Catch Accounting System through 2014.

Changes in the assessment methodology:

1) For the first time, this report uses the Joint Plan Team survey averaging working group's recommendation of a random effects (RE) model for estimating biomass. Estimates from the RE model were used for making harvest recommendations, and the report includes a comparison of the RE results to the 3-survey averages used in earlier assessments.

Summary of Results

1) The 2013 survey biomass estimates for longnose skate and "other skates" increased substantially relative to the 2011 estimate, with CVs similar to earlier years. The estimate for longnose skates is the highest in the 1984-2013 time series.

2) The 2013 survey biomass estimate for big skate was down considerably from 2011, when the biomass estimate was inflated by an anomalous single large tow of big skates in the EGOA during the 2011 survey. The 2013 estimate for the WGOA was the highest since 1999, while the estimate for the CGOA, where the majority of big skate biomass is typically observed, decreased by almost half.

3) Application of the RE model to the survey data for big, longnose, and "other skates" provided reliable estimates of biomass that the author considers superior to the 3-survey averages used in

previous assessments. Therefore, the RE estimates were used in developing harvest recommendations.

4) Estimates of incidental catches increased substantially for longnose skates and "other skates" in 2013, mainly in the IFQ halibut target fishery. It is likely that this increase in estimated catch is due to the addition of observer coverage in the IFQ halibut fishery in 2013.

5) In 2013 the catch of big skates in the CGOA exceeded the ABC for that area, as it has every year since 2010.

6) Catches in 2014 are on track to be much lower than in the preceding years. This is likely due to the fact that skates were placed on prohibited status early in 2014 as a result of the catch overages in earlier years.

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. For all species summary tables below, the 2014/2015 recommendations use a three year average of the most recent trawl survey biomass estimates (2009, 2011, 2013). For 2015/2016 a RE model was used to estimate biomass for most recent survey year (2013).

big skate (*Beringraja binoculata*)					
		As estimated or *specified last* year for		As estimated or *recommended this* year for:	
Quantity		*2014*	*2015*	**2015**	2016
M (natural mortality)		*0.1*	*0.1*	**0.1**	0.1
Specified/recommended Tier		*5*	*5*	**5**	5
Biomass (t) *2015/2016 recommendations are made using the random effects model; 2014/2015 recommendations used the 3-survey average*	W	*7,857*	*7,857*	**9,775**	9,775
	C	*20,421*	*20,421*	**16,810**	16,810
	E	*21,877*	*21,877*	**16,954**	16,954
	GOA-wide[1]	*50,155*	*50,155*	**43,398**	43,398
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	*5,016*	*5,016*	**4,340**	4,340
ABC (t; equal to maximum ABC)	W	*589*	*589*	**731**	731
	C	*1,532*	*1,532*	**1,257**	1,257
	E	*1,641*	*1,641*	**1,267**	1,267
Status		As determined *last* year for:		As determined *this* year for:	
		2012	2013	**2013**	2014
Overfishing?		*no*	*na*	**no**	na
(for Tier 5 stocks, data are not available to determine whether the stock is in an overfished condition)					

[1] The GOA-wide biomass estimate was made using a separate GOA-wide random-effects model, so the sum of the area-specific estimates does not equal the GOA-wide estimate.

longnose skate (*Raja rhina*)					
		As estimated or *specified last* year for		As estimated or *recommended this* year for:	
Quantity		*2014*	*2015*	**2015**	2016
M (natural mortality)		*0.1*	*0.1*	**0.1**	0.1
Specified/recommended Tier		*5*	*5*	**5**	5
Biomass (t) *2015/2016 recommendations are made using the random effects model; 2014/2015 recommendations used the 3-survey average*	W	*1,427*	*1,427*	**2,009**	2,009
	C	*25,806*	*25,806*	**27,575**	27,575
	E	*11,116*	*11,116*	**12,873**	12,873
	GOA-wide[1]	*38,349*	*38,349*	**42,911**	42,911
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	*3,835*	*3,835*	**4,291**	4,291
ABC (t; equal to maximum ABC)	W	*107*	*107*	**152**	152
	C	*1,935*	*1,935*	**2,090**	2,090
	E	*834*	*834*	**976**	976
		As determined *last* year for:		As determined *this* year for:	
Status		2012	2013	**2013**	2014
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)					

[1] The GOA-wide biomass estimate was made using a separate GOA-wide random-effects model, so the sum of the area-specific estimates does not equal the GOA-wide estimate.

other skates (*Bathyraja* sp.)					
		As estimated or *specified last* year for		As estimated or *recommended this* year for:	
Quantity		*2014*	*2015*	**2015**	2016
M (natural mortality)		*0.1*	*0.1*	**0.1**	0.1
Specified/recommended Tier		*5*	*5*	**5**	5
Biomass (t)	GOA-wide	26,518	26,518	**29,797**	29,797
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	2,652	2,652	**2,980**	2,980
ABC (t; equal to maximum ABC)	GOA-wide	1,989	1,989	**2,235**	2,235
		As determined *last* year for:		As determined *this* year for:	
Status		2012	2013	**2013**	2014
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

Plan Team September 2014: "The Teams recommend that stock assessment authors calculate biomass for Tier 5 stocks based on the random effects model and compare these values to status quo."

> *Response*: The random effects model was used to generate biomass estimates and harvest recommendations for big, longnose, and other skates. The results were compared to the 3-survey average using a table and several figures.

Responses to SSC and Plan Team Comments Specific to this Assessment

SSC December 2013: "The SSC also supports the Plan Team recommendation for the author to fill out the stock structure template for GOA skates for Plan Team consideration in September 2014 and further recommends the author complete a full assessment for 2014."

> *Response*: A full assessment was prepared for 2014 and is presented here. A stock structure report was presented in September 2014 and is attached to this report as an appendix.

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 Gulf of Alaska. 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

<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, and this combined with the common practice of managing skate species within aggregate complexes 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), and 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)."

<u>Life history and stock structure (Alaska-specific)</u>

Information on fecundity in North Pacific skate species is extremely limited. There are one to seven embryos per egg case in locally occurring *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 Gulf of Alaska 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 Gulf of Alaska 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

Until 2003, skates were primarily caught incidentally in longline and trawl fisheries targeting Pacific halibut and other groundfish (Table 4). Skates became economically valuable in 2003 when the ex-vessel price became equivalent to that of Pacific cod. In 2003, vessels began retaining and delivering skates as a target species in federal waters partly because the market for skates had improved, and partly because catch of Pacific cod could be retained as bycatch in a skate target fishery, even though directed fishing for cod was seasonally closed. This resulted in greater landings of skates in 2003 (Table 4). Lower ex-vessel prices and a possible reduction in skate catch-per-unit effort (T. Pearson, NMFS AKRO, pers. comm.) resulted in a sharp decline in skate catches in 2004-2005. Directed fishing for skates in the GOA has been prohibited since 2005.

Interest in retention of skates and directed fishing for skates remains high (Table 7). 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). 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 longline fisheries (Table 6). Reported retention rates of big and longnose skates was high during the late 2000s, but has declined in 2013 &2014 (Table 7). The 2013 decline may be due to increased observer coverage of the IFQ halibut fishery, where skates are less likely to be retained. In addition, retention of big skate was limited in 2013 & 2014 through management actions. In 2013, retention of big skate was prohibited in the CGOA on May 8 and in 2014, it was prohibited beginning on February 5. These actions reduced retention of big skate but may have increased the retention of longnose and other skates.

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 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 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.

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, which 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 2009-2013 for big skate (Figure 6) and longnose skate (Figure 7). These data suggest that fisheries are capturing a narrower size range of longnose skate relative to big skate. Length compositions do not vary substantially among trawl and longline fisheries (Figure 8); 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, we use the NMFS summer bottom trawl surveys 1984-2013 as our primary source of information on the biomass and distribution of the major skate species (Tables 2, 3 & 8; Figures 9-11). On a gulf-wide basis, big and longnose skate biomass estimates have been fairly stable since the late 1990s (Table 2 & Figure 9). Area-specific biomass has shown greater fluctuations (Table 8 & Figure 10); in particular, big skate biomass has decreased dramatically in the CGOA since 2003. "Other skate" biomass increased in 2013, reversing a declining trend that occurred during 2005-2011 (Table 2 & Figure 11).

Random effects model biomass estimates: Previous assessments used a 3-survey running average to produce a biomass estimate for use in developing harvest specifications. For the 2014 assessment, biomass was also estimated using a random effects (RE) model developed by the Joint Plan Team Survey Averaging Working Group. Estimates were produced for big and longnose skate on an area-specific and gulfwide basis (Tables 9a, 9b & Figures 12, 13); and for other skates on a gulfwide basis only (Table 9c). 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 14). 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 (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 pre-2011 data for longnose skates displayed a clear size mode at approximately 120 cm (Figure 15). 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 16). The largest big skates tend to be found in the Western GOA and the smallest big skates in the Eastern GOA. Intermediate sizes dominate in the Central GOA, 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 17). 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.

Random effects (RE) models were used in two ways to make harvest recommendations. A separate gulfwide RE model was run for each species or species group (big, longnose, and other skates). The results of that model (i.e. the 2013 RE model biomass estimate) was used to calculate gulfwide OFLs and ABCs. For big skate and longnose skate, the gulfwide ABC was apportioned to each regulatory area according to the proportion of biomass in each area. For apportionment, area-specific RE model results were used.

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 di not include the best 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. It was not possible to properly review the treatment of M for this assessment in time for the September 2014 Plan Team meetings; such a review is planned for the 2015 SAFE report. For this year the assessment continues to use the 0.1 value for all skates.

Results

Harvest recommendations

big skate (*Beringraja binoculata*)					
Quantity		As estimated or *specified last* year for *2014*	*2015*	As estimated or *recommended this* year for: **2015**	2016
M (natural mortality)		*0.1*	*0.1*	**0.1**	0.1
Specified/recommended Tier		*5*	*5*	**5**	5
Biomass (t) *2015/2016 recommendations are made using the random effects model; 2014/2015 recommendations used the 3-survey average*	W	*7,857*	*7,857*	**9,775**	9,775
	C	*20,421*	*20,421*	**16,810**	16,810
	E	*21,877*	*21,877*	**16,954**	16,954
	GOA-wide[1]	*50,155*	*50,155*	**43,540**	43,540
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	*5,016*	*5,016*	**4,354**	4,354
ABC (t; equal to maximum ABC)	W	*589*	*589*	**733**	733
	C	*1,532*	*1,532*	**1,261**	1,261
	E	*1,641*	*1,641*	**1,272**	1,272
Status		As determined *last* year for: 2012	2013	As determined *this* year for: **2013**	2014
Overfishing?		*no*	*na*	**no**	na
(for Tier 5 stocks, data are not available to determine whether the stock is in an overfished condition)					

[1] The GOA-wide biomass estimate was made using a separate GOA-wide random-effects model, so the sum of the area-specific estimates does not equal the GOA-wide estimate.

longnose skate (*Raja rhina*)					
Quantity		As estimated or *specified last* year for *2014*	*2015*	As estimated or *recommended this* year for: **2015**	2016
M (natural mortality)		*0.1*	*0.1*	**0.1**	0.1
Specified/recommended Tier		*5*	*5*	**5**	5
Biomass (t) *2015/2016 recommendations are made using the random effects model; 2014/2015 recommendations used the 3-survey average*	W	*1,427*	*1,427*	**2,009**	2,009
	C	*25,806*	*25,806*	**27,575**	27,575
	E	*11,116*	*11,116*	**12,873**	12,873
	GOA-wide[1]	*38,349*	*38,349*	**42,457**	42,457
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	*3,835*	*3,835*	**4,426**	4,426
ABC (t; equal to maximum ABC)	W	*107*	*107*	**151**	151
	C	*1,935*	*1,935*	**2,068**	2,068
	E	*834*	*834*	**965**	965
Status		As determined *last* year for: 2012	2013	As determined *this* year for: **2013**	2014
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)					

[1] The GOA-wide biomass estimate was made using a separate GOA-wide random-effects model, so the sum of the area-specific estimates does not equal the GOA-wide estimate.

other skates (*Bathyraja* sp.)					
Quantity		As estimated or *specified last* year for *2014*	*2015*	As estimated or *recommended this* year for: **2015**	2016
M (natural mortality)		*0.1*	*0.1*	**0.1**	0.1
Specified/recommended Tier		*5*	*5*	**5**	5
Biomass (t)	GOA-wide	26,518	26,518	**29,418**	29,418
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	2,652	2,652	**2,942**	2,942
ABC (t; equal to maximum ABC)	GOA-wide	1,989	1,989	**2,206**	2,206
Status		As determined *last* year for: 2012	2013	As determined *this* year for: **2013**	2014
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. All of this research has been initiated for major skate species in the GOA; it should be fully funded to completion.

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.

Acknowledgements

The information in this assessment has benefited greatly from the hard work of previous assessment authors, especially Sarah Gaichas (AFSC). We also thank all of the AFSC and ADF&G personnel who have provided data, advice, and other assistance.

Literature Cited

Agnew, D.J., C.P. Nolan, J.R. Beddington, and R. Baranowski, 2000. Approaches to the assessment and management of multispecies skate and ray fisheries using the Falkland Islands fishery as an example. Can. J. Fish. Aquat. Sci. 57: 429-440.

Allen, M.J., and G.B. Smith, 1988. Atlas and zoogeography of common fishes in the Bering Sea and northeastern Pacific. NOAA Technical Report NMFS 66, 151 pp.

Alverson, D.L., and W.T. Pereyra, 1969. Demersal fish explorations in the northeastern Pacific Ocean: An evaluation of exploratory fishing methods and analytical approaches to stock size and yield forecasts. J. Fish. Res. Bd. Canada 26: 1985-2001.

Alverson, D.L., and M.J. Carney. 1975. A graphic review of the growth and decay of population cohorts. J. Cons. Int. Explor. Mer 36:133-143.

Aydin, K., S. Gaichas, I. Ortiz, D. Kinzey, and N. Friday. 2007. A comparison of the Bering Sea, Gulf of Alaska, and Aleutian Islands large marine ecosystems through food web modeling. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-178, 298 p.

Brander, K., 1981. Disappearance of common skate *Raja batis* from Irish Sea. Nature 290: 48-49.

Casey, J.M. and R.A. Myers, 1998. Near extinction of a large, widely distributed fish. Science 281(5377):690-692.

Charnov, E.L. 1993. Life history invariants some explorations of symmetry in evolutionary ecology. Oxford University Press Inc., New York. 167p.

Dulvy, N.K., J.D. Metcalfe, J. Glanville, M.G. Pawson, and J.D. Reynolds, 2000. Fishery stability, local extinctions, and shifts in community structure in skates. Conservation Biology 14(1): 283-293.

Eschmeyer, W.N., E.S. Herald, and H. Hammann, 1983. A field guide to Pacific coast fishes of North America. Houghton Mifflin Co., Boston: 336 pp.

Frisk, M.G., T. J. Miller, and M. J. Fogarty, 2001. Estimation and analysis of biological parameters in elasmobranch fishes: a comparative life history study. Can. J. Fish. Aquat. Sci. 58: 969-981.

Frisk, M. G. , T. J. Miller, and M. J. Fogarty, 2002. The population dynamics of little skate *Leucoraja erinacea*, winter skate *Leucoraja ocellata*, and barndoor skate *Dipturus leavis*: predicting exploitation limits using matrix analysis. ICES J. Mar. Sci. 59: 576-586.

Gaichas, S., J. Ianelli, and L. Fritz, 1999. Other species considerations for the Gulf of Alaska.

Gburski, C.M., S.K. Gaichas, and D.K. Kimura. 2007. Age and growth of big skate (*Raja binoculata*) and longnose skate (*R. rhina*) and implications to the skate fisheries in the Gulf of Alaska. Env. Bio. Fishes 80: 337-349.

Hoenig, J.M., 1983. Empirical use of longevity data to estimate mortality rates. Fish. Bull. 82(1): 898-902.

Hoff, G.R. 2007. Reproductive biology of the Alaska skate Bathyraja parmifera, with regard to nursery sites, embryo development and predation. Ph.D. Dissertation, University of Washington, Seattle. 161 pp.

Ishihara, H. and R. Ishiyama, 1985. Two new North Pacific skates (Rajidae) and a revised key to *Bathyraja* in the area. Jpn. J. Ichthyol. 32(2): 143-179.

King, J. R., and G. A. McFarlane, 2002. Preliminary results of Big Skate (*Raja binoculata*) Age Determination Project. Unpub. Man. DFO.

King, J.R., and G.A. McFarlane, 2003. Marine fish life history strategies: applications to fishery management. Fish. Man. And Ecology, 10: 249-264.

Kotwicki, S., and Weinberg, K.L. 2005. Estimating capture probability of a survey bottom trawl for Bering Sea skates (*Bathyraja spp.*) and other fish. Alaska Fishery Research Bulletin 11(2): 135-145.

Love, M.S., C.W. Mecklenberg, T.A. Mecklenberg, and L.K. Thorsteinson. 2005. Resource inventory of marine and estuarine fishes of the West Coast and Alaska: a checklist of north Pacific and Arctic Ocean species from Baja California to the Alaska-Yukon Border. U.S. Department of the Interior, U.S. Geological Survey, Biological Resources Division, Seattle, Washington, 98104, OCS Study MMS 2005-030 and USGS/NBII 2005-001.

Martin, L. and G.D. Zorzi, 1993. Status and review of the California skate fishery. In Conservation biology of elasmobranchs (S. Branstetter, ed.), p. 39-52. NOAA Technical Report NMFS 115.

McEachran, J.D., and K.A. Dunn, 1998. Phylogenetic analysis of skates, a morphologically conservative clade of elasmobranchs (Chondrichthyes: Rajidae). Copeia, 1998(2), 271-290.

McEachran, J.D. and T. Miyake, 1990a. Phylogenetic relationships of skates: a working hypothesis (Chondrichthyes: Rajoidei). In Elasmobranchs as living resources: advances in the biology, ecology, systematics, and the status of the fisheries (H.L. Pratt, Jr., S.R. Gruber, and T. Taniuchi, eds.), p. 285-304. NOAA Technical Report NMFS 90.

McEachran, J.D. and T. Miyake, 1990a. Phylogenetic relationships of skates: a working hypothesis (Chondrichthyes: Rajoidei). In Elasmobranchs as living resources: advances in the biology, ecology, systematics, and the status of the fisheries (H.L. Pratt, Jr., S.R. Gruber, and T. Taniuchi, eds.), p. 285-304. NOAA Technical Report NMFS 90.

McFarlane, G.A. and J.R. King. 2006. Age and growth of big skate (*Raja binoculata*) and longnose skate (*Raja rhina*) in British Columbia waters. Fish Res. 78: 169-178.

Moyle, P.B., and J.J. Cech, Jr., 1996. Fishes, an introduction to ichthyology (Third edition). Prentice Hall: New Jersey, 590 pp.

Murray, J.D., 1989. Mathematical Biology. Springer-Verlag: New York. 767 pp.

Musick, J.A., S.A. Berkeley, G.M. Cailliet, M. Camhi, G. Huntsman, M. Nammack, and M.L. Warren, Jr., 2000. Protection of marine fish stocks at risk of extinction. Fisheries 25(3):6-8.

Nelson, J. S., 1994. Fishes of the world, Third edition. John Wiley and Sons, Inc., New York: 600 pp.

NMFS 2000. Skate complex. In Draft 30th Northeast Regional Stock Assessment Workshop (30th SAW), Stock assessment review committe (SARC) consensus summary of assessments, p. 7-173.

NMFS PSEIS 2001. Draft Programmatic Environmental Impact Statement.

Orlov, A.M., 1998. The diets and feeding habits of some deep-water benthic skates (Rajidae) in the Pacific waters off the northern Kuril Islands and southeastern Kamchatka. Alaska Fishery Research Bulletin 5(1): 1-17.

Orlov, A.M., 1999. Trophic relationships of commercial fishes in the Pacific waters off southeastern Kamchatka and the northern Kuril Islands. Pages 231-263 in Ecosystem Approaches for Fishery Management, Alaska Sea Grant College Program AK-SG-99-01, University of Alaska Fairbanks, 756 pp.

Pauly, D. On the interrelationships between natural mortality, growth parameters, and mean environmental temperature in 175 fish stocks. J. Cons. Int. Explor. Mer 39(2):175-192.

Rikhter, V.A., and V.N. Efanov. 1976. On one of the approaches to estimation of natural mortality of fish populations. ICNAF Res. Doc. 76/VI/8. Serial N. 3777. 13p.

Roff, D.A. 1986. The evolution of life history parameters in teleosts. Can. J. Fish. Aquat. Sci. 41:989-1000.

Sosebee, K., 1998. Skates. In Status of Fishery Resources off the Northeastern United States for 1998 (Stephen H. Clark, ed.), p. 114-115. NOAA Technical Memorandum NMFS-NE-115.

Stevenson, D. 2004. Identification of skates, sculpins, and smelts by observers in north Pacific groundfish fisheries (2002-2003), U.S. Department of Commerce Technical Memorandum NMFS-AFSC-142. 67 p.

Stevenson, D.E., J.W. Orr, G.R. Hoff, and J.D. McEachran. 2004. *Bathyraja mariposa*: a new species of skate (Rajidae: Arhynchobatinae) from the Aleutian Islands. Copeia 2004(2):305-314.

Stevenson, D. E., Orr, J. W., Hoff, G. R., and McEachran, J. D. 2007. Field guide to sharks, skates, and ratfish of Alaska. Alaska Sea Grant.

Thompson, G.G., 1993. A proposal for a threshold stock size and maximum fishing mortality rate. Pages 303-320 in Risk evaluation and biological reference points for fisheries management (S.J. Smith, J.J. Hunt, and D. Rivard, eds.). Can. Spec. Publ. Fish. Aquat. Sci. 120, 440 pp.

Wakefield, W.W. 1984. Feeding relationships within assemblages of nearshore and mid-continental shelf benthic fishes off Oregon. M.S. Thesis, OSU.

Walker, P.A., and R. G. Hislop, 1998. Sensitive skates or resilient rays? Spatial and temporal shifts in ray species composition in the central and north-western North Sea between 1930 and the present day. ICES J. Mar Sci., 55: 392-402.

Winemiller, K.O., and K.A. Rose, 1992. Patterns of life history diversification in North American fishes: implications for population regulation. Can. J. Fish. Aquat. Sci. 49: 2196-2218.

Zeiner, S.J. and P. Wolf, 1993. Growth characteristics and estimates of age at maturity of two species of skates (*Raja binoculata* and *Raja rhina*) from Monterey Bay, California. In Conservation biology of elasmobranchs (S. Branstetter, ed.), p. 39-52. NOAA Technical Report NMFS 115.

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, 1984-2013. CV = coefficient of variation.

year	big skate		longnose skate		other skates		total skate biomass (t)
	biomass (t)	CV	biomass (t)	CV	biomass (t)	CV	
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	41,449	0.08	30,063	0.11	110,832
2007	38,458	0.19	34,421	0.11	32,334	0.11	105,212
2009	44,349	0.16	36,652	0.09	27,461	0.12	108,463
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

Table 3. Bottom trawl survey biomass estimates (t) for skates in each GOA regulatory area, 1984-2013.

		1984	1987	1990	1993	1996	1999	2001	2003	2005	2007	2009	2011	2013
WGOA	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
	longnose	0	41	1,045	105	278	1,747	104	782	1,719	628	1,214	941	2,127
	skate unid	325	259	0	12	13	1	3	1	38	22	850	28	0
	Bathyraja sp	0	91	0	651	453	0	0	0	0	0	0	0	0
	Bering	45	20	28	0	52	218	170	39	86	0	283	237	37
	mud	0	0	0	0	0	46	0	0	0	0	10	7	0
	roughtail	0	0	0	0	43	0	0	0	0	82	0	0	0
	Alaska	0	0	0	0	119	220	1,213	265	211	177	1,728	333	1,124
	Aleutian	358	112	139	292	82	1,928	1,858	4,401	1,453	3,333	3,051	873	2,970
	whiteblotched	0	0	0	0	0	544	0	173	502	197	199	487	0
	whitebrow	0	0	0	0	0	0	0	0	0	33	0	0	0
	total WGOA	**4,067**	**4,837**	**2,956**	**3,348**	**14,168**	**15,741**	**11,774**	**15,264**	**13,799**	**10,344**	**13,987**	**9,157**	**16,926**
CGOA	big	17,635	20,855	9,071	21,586	26,544	34,007	30,658	33,814	25,544	23,249	26,691	21,761	12,810
	longnose	2,280	2,667	8,708	14,158	20,328	29,872	23,171	25,741	29,853	26,034	25,534	23,609	28,274
	skate unid	2,108	1,241	9,618	30	126	32	19	32	58	24	78	21	0
	Bathyraja sp	0	32	0	3,572	1,566	0	14	1	0	16	0	0	0
	Bering	230	519	1,861	107	1,492	3,371	2,423	3,526	3,910	3,466	3,370	3,429	3,501
	mud	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
	Alaska	0	14	771	0	810	1,272	2,422	1,579	489	1,618	1,021	708	2,907
	Aleutian	1,235	601	896	60	5,681	8,055	4,734	10,772	22,395	21,928	15,725	13,409	17,972
	whiteblotched	0	0	0	0	0	925	0	0	0	0	0	0	0
	whitebrow	8	0	0	0	0	0	0	0	0	84	0	0	72
	total CGOA	**23,548**	**26,112**	**30,924**	**39,513**	**56,546**	**78,148**	**63,440**	**75,465**	**82,389**	**76,914**	**72,775**	**62,937**	**65,537**
EGOA	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
	longnose	6,722	3,923	2,242	3,539	5,620	7,714		13,081	9,876	7,759	9,904	9,362	14,083
	skate unid	96	173	143	877	5	42		3	19	15	23	2	0
	Bathyraja sp	0	0	0	470	3	0		0	17	0	0	0	0
	Bering	187	68	159	119	673	229		136	341	335	473	191	426
	mud	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
	Alaska	4	0	107	0	0	76		63	0	0	0	0	0
	Aleutian	0	25	216	0	796	1,310		640	406	138	295	1,663	1,697
	whiteblotched	0	0	0	0	0	0		91	0	0	0	0	0
	whitebrow	0	0	0	0	0	0		52	0	0	0	0	0
	total EGOA	**13,575**	**7,114**	**14,367**	**20,841**	**10,487**	**19,040**		**26,046**	**14,643**	**17,955**	**21,701**	**51,089**	**30,960**
GOA-wide		**41,189**	**38,063**	**48,248**	**63,702**	**81,201**	**112,929**	**75,214**	**116,775**	**110,832**	**105,212**	**108,463**	**123,183**	**113,423**

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		W	C	E	E_2
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		711		719
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		1393		1,414
2007	big	695	2,250	599	4,726	69	1,518	8	11
	longnose	65	1,969	861	3,860	**76**	982	343	389
	other		1,617		2,156		1,259		1,279
2008	big	632	2,065	633	4,439	132	1,241	45	49
	longnose	78	2,041	768	3,849	34	966	114	131
	other		2,104		2,806		1,379		1,413
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		1,548		1,595
2010	big	598	2,049	681	4,438	148	**2,214**	149	179
	longnose	81	2,009	762	3,803	**105**	846	131	197
	other		2,093		2,791		1,491		1,526
2011	big	598	2,049	681	4,438	110	**2,105**	90	134
	longnose	81	2,009	762	3,803	71	892	68	118
	other		2,093		2,791		1,351		1,388
2012	big	469	1,793	1,505	5,023	66	**1,894**	38	62
	longnose	70	1,879	676	3,500	39	793	93	134
	other		2,030		2,706		1,200		1,237
2013	big	469	1,793	1,505	5,023	121	**2,304**	79	221
	longnose	70	1,879	676	3,500	**90**	1,260	426	**846**
	other		2,030		2,706		1,879		**2,075**
2014*	big	589	1,532	1,641	5,016	*124*	*1,086*	*81*	*176*
	longnose	107	1,935	834	3,835	*47*	*939*	*328*	*530*
	other		1,989		2,652		*1,467*		*1,672*

Table 6a. Catches of **big skate** (t) by target fishery, 2004-2014. Data are from the Alaska Regional Office Catch Accounting System. * 2014 are incomplete; retrieved October 8, 2014.

big skate											
	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	*2014**
arrowtooth	140	225	163	299	219	433	478	812	677	949	*170*
Pacific cod	331	222	417	539	587	559	948	961	755	650	*646*
IFQ halibut	24	37	608	11	34	171	43	145	39	523	*345*
pollock	1	2	23	38	22	34	47	93	48	212	*172*
rex sole	31	49	99	74	70	264	172	106	140	145	*25*
shallow flatfish	237	251	350	608	413	535	700	190	288	140	*23*
flathead sole	38	21	30	23	66	53	112	31	57	15	*0*
sablefish	6	24	10	7	6	7	12	2	4	9	*3*
rockfish	16	19	4	0	4	4	14	8	13	2	*3*
deep flatfish	4	0	0	0	0	0	1	1	0	0	*0*
total	1,204	904	1,732	1,598	1,422	2,119	2,541	2,350	2,022	2,646	*1,386*

Table 6b. Catches of **longnose skate** by target fishery, 2003-2014. Data are from the Alaska Regional Office Catch Accounting System. * 2014 are incomplete; retrieved October 8, 2014.

longnose skate												
	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	*2014**
IFQ halibut	1	35	106	210	424	109	444	112	196	122	1,003	*519*
Pacific cod	10	83	139	165	307	361	352	430	375	327	435	*293*
sablefish	16	120	113	352	303	138	88	116	75	134	351	*183*
arrowtooth	14	63	373	135	165	212	152	166	238	181	224	*275*
shallow flatfish	3	26	278	97	168	227	239	172	78	65	70	*30*
rex sole	0	13	19	29	24	36	82	52	44	45	54	*23*
pollock	0	0	5	13	27	24	35	10	35	9	25	*161*
rockfish	1	32	20	21	17	12	17	12	25	23	23	*21*
flathead sole	9	7	11	11	13	11	24	30	17	60	8	*11*
Atka mackerel	0	0	0	0	0	0	0	0	0	0	1	*0*
deep flatfish	0	3	1	0	0	0	0	1	0	0	0	*0*
total	53	537	1,202	1,035	1,447	1,130	1,495	1,148	1,082	965	2,196	*1,516*

Table 6c. Catches of "**Other skates**" by target fishery, 2003-2014. Data are from the Alaska Regional Office Catch Accounting System. * 2014 are incomplete; retrieved October 8, 2014.

	Other skates											
	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	*2014**
Pacific cod	0	0	0	0	0	0	0	0	2	0	0	*0*
IFQ halibut	9	1	1	5	8	5	2	5	1	4	9	*12*
sablefish	191	44	38	12	20	5	13	19	13	17	8	*1*
arrowtooth	0	1	0	0	0	0	0	0	0	0	0	*1*
shallow flatfish	1,971	251	2	3	4	16	30	0	0	0	0	*0*
rex sole	806	490	175	981	531	959	908	1,077	800	704	910	*728*
pollock	11	2	1	5	9	6	3	7	2	6	24	*14*
rockfish	346	46	36	56	103	22	60	41	21	19	33	*21*
flathead sole	346	46	36	56	103	22	60	41	21	19	33	*21*
Atka mackerel	105	19	59	49	20	10	13	28	14	20	18	*22*
deep flatfish	559	65	36	27	79	107	98	35	20	32	44	*18*
total	4,448	984	444	1,241	898	1,160	1,201	1,281	909	840	1,097	*860*

Table 7. Retention rates of skates in GOA fisheries, 2007-2014. Data are from tables published by the Alaska Regional Office. 2014 data are incomplete; retrieved November 3, 2014. Retention rates in 2013 & 2014 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]	*6%*	*32%*	*49%*

[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.
* 2014 data are incomplete; retrieved November 3, 2014

Table 8a. Bottom trawl survey biomass estimates (t) for big skates by regulatory area, 1984-2013. 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

Table 8b. Bottom trawl survey biomass estimates (t) for longnose skates by regulatory area, 1984-2013. 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

Table 9a. Comparison of big skate biomass estimates (t) from 3 sources: single survey estimates, 3-survey averages, and a random effects (RE) model, 1984-2013, by regulatory area.

	big skate WGOA				big skate CGOA				big skate EGOA			
	survey est.	3-survey ave.	RE est.	RE CV	survey est.	3-survey ave.	RE est.	RE CV	survey est.	3-survey ave.	RE est.	RE CV
1984	3,339		3,418	0.21	17,635		18,412	0.18	6,566		5,645	0.48
1985			3,619	0.32			18,643	0.18			5,234	0.51
1986			3,832	0.31			18,878	0.17			4,854	0.49
1987	4,313		4,058	0.15	20,855		19,115	0.14	2,925		4,501	0.41
1988			3,232	0.31			18,659	0.17			5,801	0.45
1989			2,575	0.33			18,214	0.19			7,477	0.43
1990	1,745	3,132	2,051	0.23	9,071	15,854	17,780	0.20	11,501	6,997	9,638	0.33
1991			2,211	0.33			18,938	0.19			10,259	0.44
1992			2,385	0.32			20,172	0.17			10,920	0.44
1993	2,287	2,782	2,571	0.17	21,586	17,171	21,486	0.14	15,836	10,087	11,623	0.34
1994			4,228	0.31			22,839	0.15			8,485	0.41
1995			6,953	0.31			24,277	0.15			6,194	0.40
1996	13,130	5,720	11,434	0.17	26,544	19,067	25,805	0.14	3,391	10,242	4,522	0.30
1997			11,238	0.31			27,116	0.15			5,574	0.40
1998			11,046	0.30			28,493	0.16			6,871	0.40
1999	11,038	8,818	10,857	0.14	34,007	27,379	29,940	0.14	9,606	9,611	8,471	0.29
2000			9,774	0.27			29,944	0.15			8,695	0.44
2001	8,425	10,864	8,799	0.17	30,658	30,403	29,948	0.14		6,498	8,926	0.48
2002			9,143	0.27			29,723	0.15			9,162	0.45
2003	9,602	9,688	9,501	0.15	33,814	32,826	29,500	0.14	11,981	10,793	9,405	0.32
2004			9,436	0.27			28,000	0.15			7,332	0.37
2005	9,792	9,273	9,372	0.15	25,544	30,005	26,575	0.13	3,984	7,982	5,715	0.32
2006			7,681	0.27			25,581	0.15			7,118	0.37
2007	5,872	8,422	6,295	0.17	23,249	27,536	24,624	0.14	9,337	8,434	8,866	0.27
2008			6,476	0.27			24,023	0.15			10,235	0.35
2009	6,652	7,439	6,662	0.15	26,691	25,161	23,437	0.13	11,007	8,109	11,817	0.26
2010			6,901	0.29			21,904	0.14			15,313	0.40
2011	6,251	6,258	7,149	0.26	21,761	23,900	20,471	0.12	39,870	20,071	19,843	0.43
2012			8,360	0.31			18,551	0.16			18,342	0.47
2013	10,669	7,857	9,775	0.23	12,810	20,421	16,811	0.18	14,755	21,877	16,954	0.44

Table 9b. Comparison of longnose skate biomass estimates (t) from 3 sources: single survey estimates, 3-survey averages, and a random effects model (RE), 1984-2013, by regulatory area.

	longnose skate WGOA				longnose skate CGOA				longnose skate EGOA			
	survey est.	3-survey ave.	RE est.	RE CV	survey est.	3-survey ave.	RE est.	RE CV	survey est.	3-survey ave.	RE est.	RE CV
1984				0.00	2,280		3,430	0.42	6,722		4,700	0.33
1985				0.00			3,574	0.39			4,361	0.33
1986				0.00			3,724	0.34			4,046	0.31
1987	41		73	0.79	2,667		3,880	0.28	3,923		3,754	0.28
1988			139	0.95			4,925	0.28			3,463	0.27
1989			264	0.92			6,251	0.26			3,195	0.26
1990	1,045		504	0.69	8,708	4,552	7,934	0.21	2,242	4,296	2,947	0.22
1991			345	0.90			9,537	0.24			3,185	0.23
1992			236	0.88			11,465	0.22			3,442	0.22
1993	105	397	162	0.62	14,158	8,511	13,782	0.13	3,539	3,235	3,721	0.16
1994			201	0.89			15,611	0.21			4,243	0.20
1995			251	0.87			17,683	0.21			4,839	0.20
1996	278	476	312	0.55	20,328	14,398	20,030	0.15	5,620	3,800	5,519	0.15
1997			473	0.84			22,136	0.21			6,162	0.20
1998			717	0.83			24,464	0.21			6,881	0.20
1999	1,747	710	1,086	0.51	29,872	21,453	27,036	0.15	7,714	5,624	7,683	0.15
2000			524	0.73			25,620	0.19			8,535	0.21
2001	104	710	253	0.68	23,171	24,457	24,277	0.13		5,624	9,481	0.22
2002			431	0.74			25,094	0.18			10,532	0.21
2003	782	878	737	0.40	25,741	26,261	25,939	0.10	13,081	8,805	11,700	0.14
2004			1,046	0.66			27,534	0.17			10,841	0.18
2005	1,719	868	1,485	0.34	29,853	26,255	29,228	0.09	9,876	10,224	10,045	0.14
2006			1,055	0.66			27,744	0.17			9,494	0.19
2007	628	1,043	750	0.42	26,034	27,209	26,335	0.11	7,759	10,239	8,973	0.17
2008			900	0.70			25,917	0.17			9,351	0.19
2009	1,214	1,187	1,080	0.50	25,534	27,140	25,505	0.09	9,904	9,180	9,744	0.15
2010			1,061	0.69			24,975	0.17			9,973	0.18
2011	941	928	1,042	0.39	23,609	25,059	24,456	0.12	9,362	9,008	10,208	0.15
2012			1,447	0.65			25,969	0.18			11,463	0.18
2013	2,127	1,427	2,009	0.31	28,274	25,806	27,575	0.13	14,083	11,116	12,873	0.16

Table 9c. Comparison of other skate biomass estimates (t) from 3 sources: single survey estimates, 3-survey averages, and a random effects model (RE), 1984-2013

	other skates GOA-wide			
	survey est.	**3-survey ave.**	**RE est.**	**RE CV**
1984	4,647		4,583	0.155
1985			4,433	0.246
1986			4,288	0.255
1987	3,339		4,148	0.193
1988			5,494	0.256
1989			7,278	0.266
1990	13,936	7,307	9,642	0.230
1991			8,591	0.264
1992			7,655	0.241
1993	6,191	7,822	6,821	0.138
1994			8,180	0.236
1995			9,809	0.238
1996	11,912	10,680	11,762	0.147
1997			13,687	0.235
1998			15,928	0.228
1999	18,946	12,350	18,535	0.110
2000			19,392	0.239
2001			20,289	0.269
2002			21,228	0.238
2003	21,775	17,544	22,210	0.108
2004			25,578	0.196
2005	30,063	23,595	29,456	0.104
2006			30,560	0.195
2007	32,334	28,057	31,706	0.099
2008			29,417	0.196
2009	27,461	29,953	27,293	0.110
2010			24,652	0.196
2011	21,389	27,061	22,266	0.097
2012			25,758	0.196
2013	30,705	26,518	29,797	0.111

.

Figures

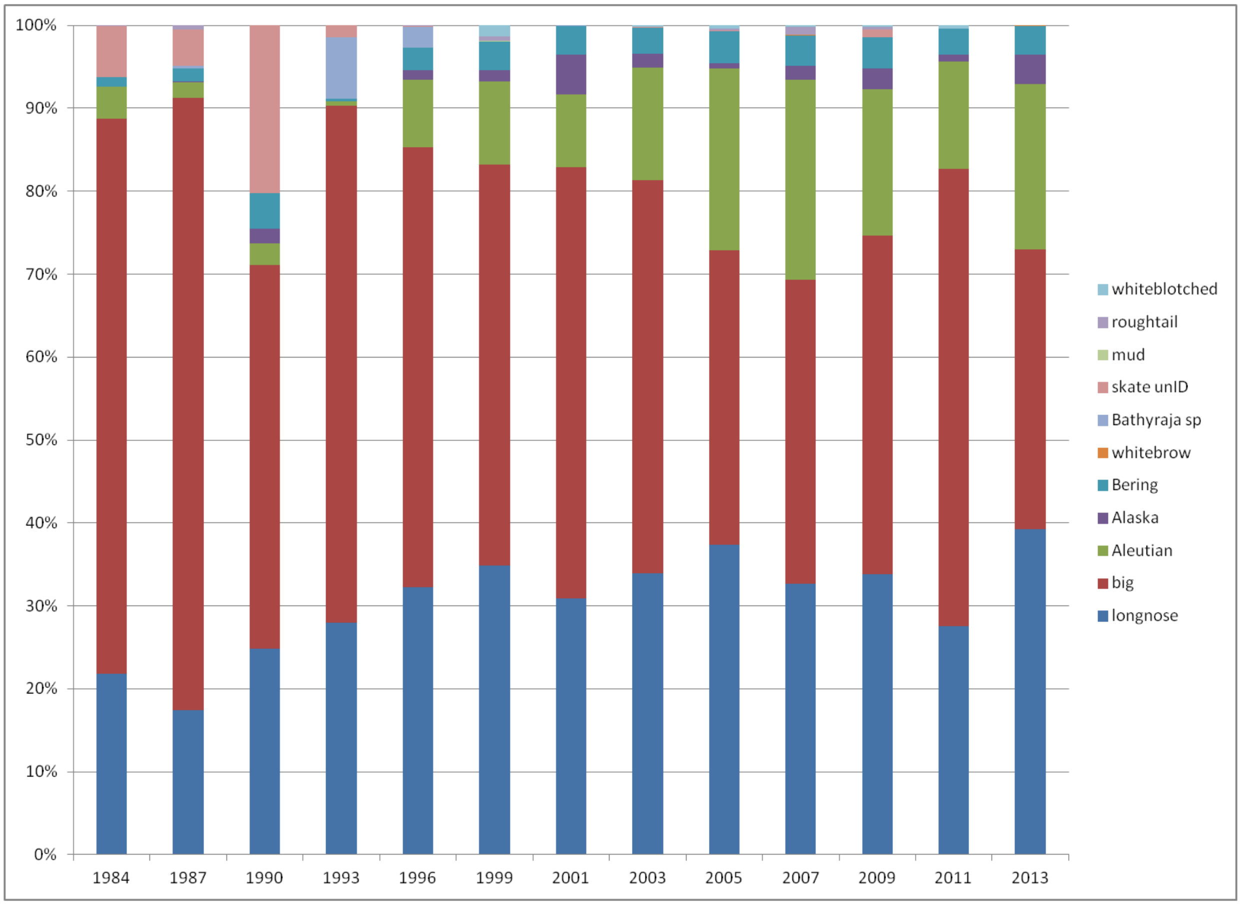


Figure 1. Gulfwide species composition of GOA skates, 1996-2013. The 2001 survey did not sample in the EGOA. The "other skates" assemblage includes all species except for big skate and longnose skate.

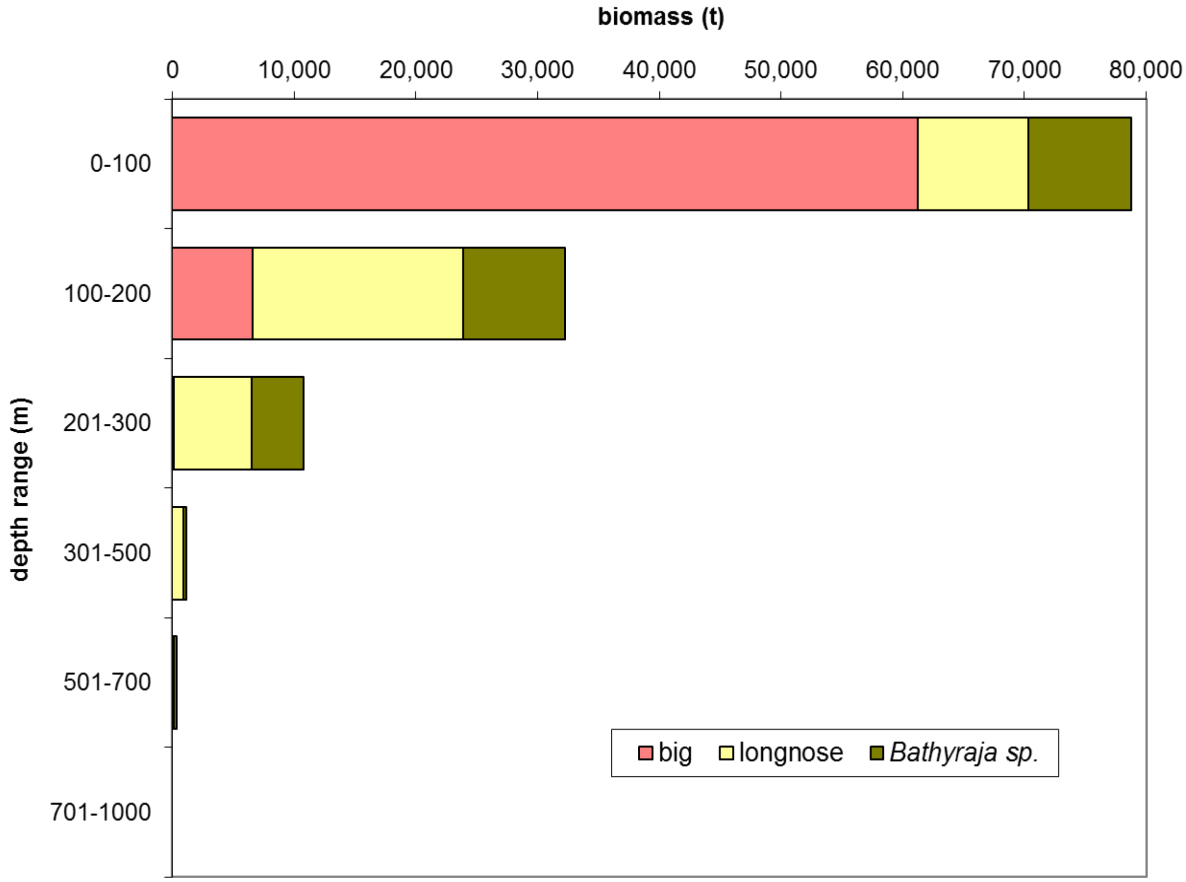


Figure 2. 2013 survey biomass estimates (t) at depth for major GOA skate species: big, longnose, and the *Bathyraja* species complex (i.e. Other Skates).

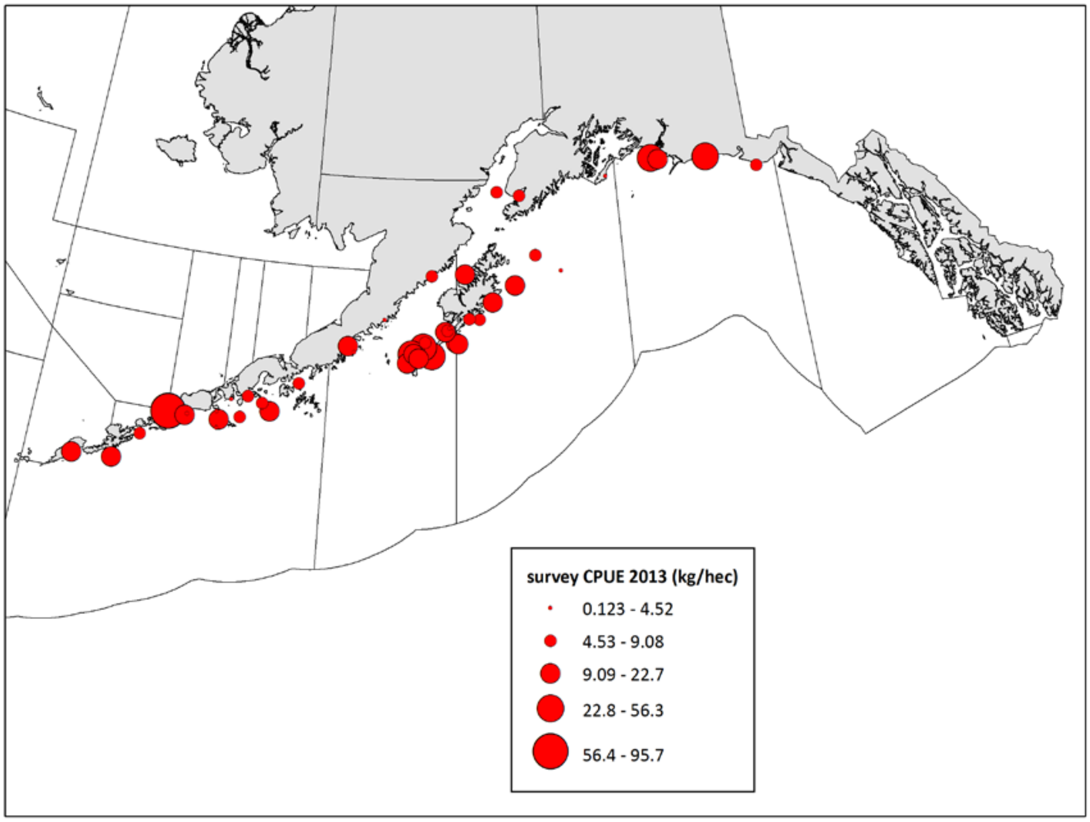


Figure 3. Trawl survey CPUE of **big** skates in 2013. Hauls with CPUE = 0 are not shown.

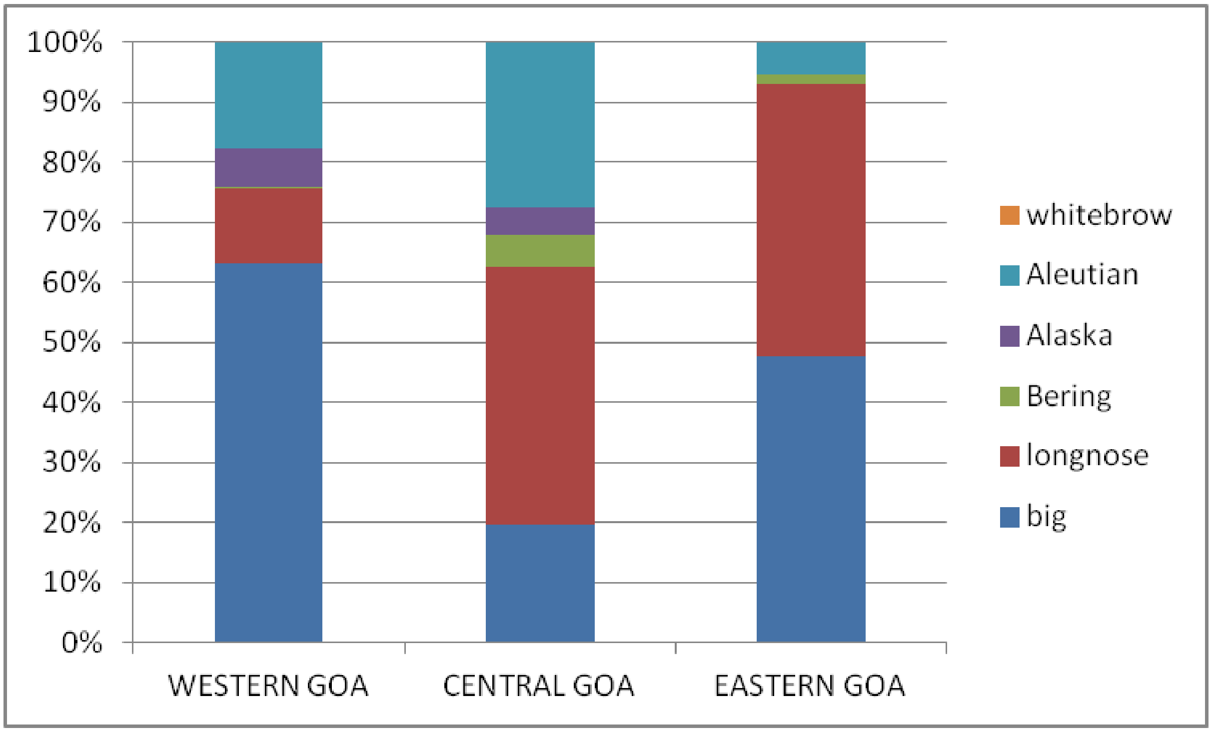


Figure 4. Species composition of GOA skates by GOA regulatory area, 2013. The “other skates” assemblage includes all species except for big skate and longnose skate.

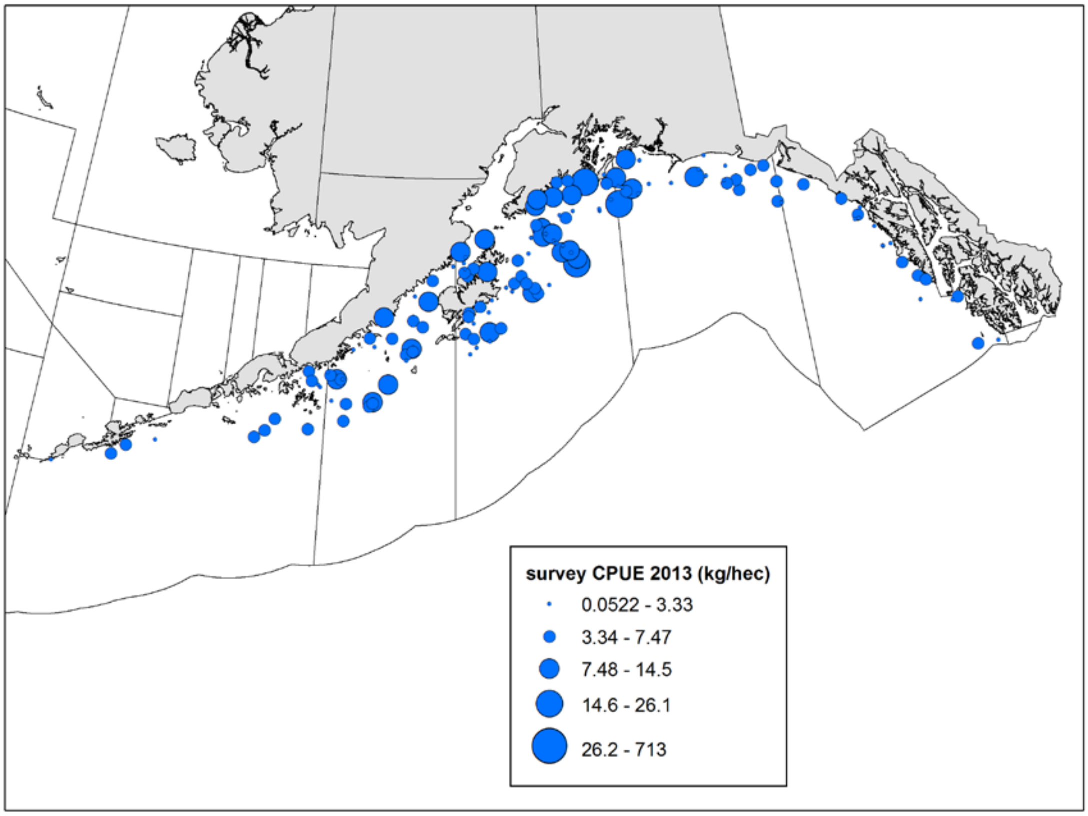


Figure 5. Trawl survey CPUE of **longnose** skates in 2013. Hauls with CPUE = 0 are not shown.

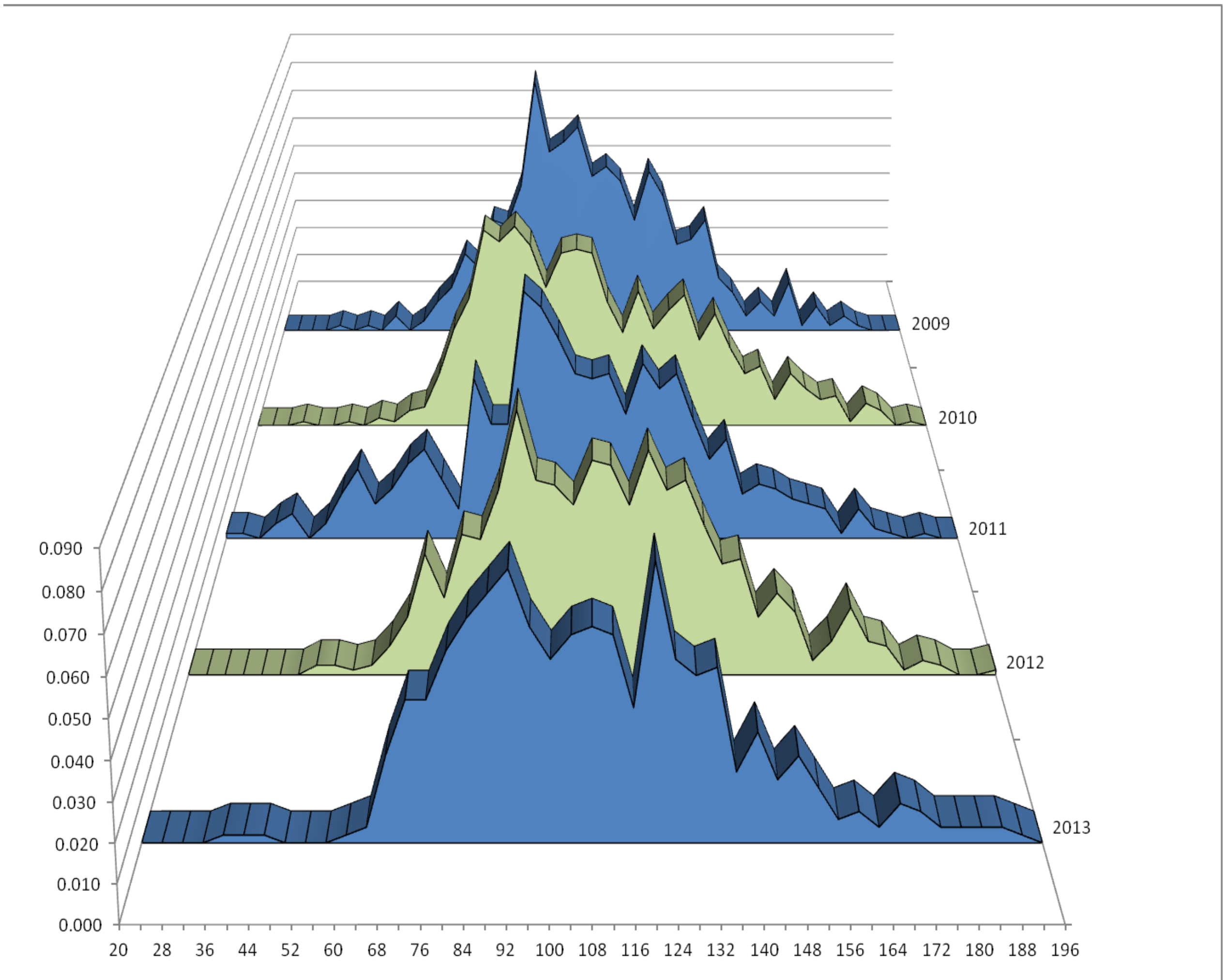


Figure 6. Length compositions of fishery catches (trawl and longline combined) for **big** skates in the GOA, 2009-2013.

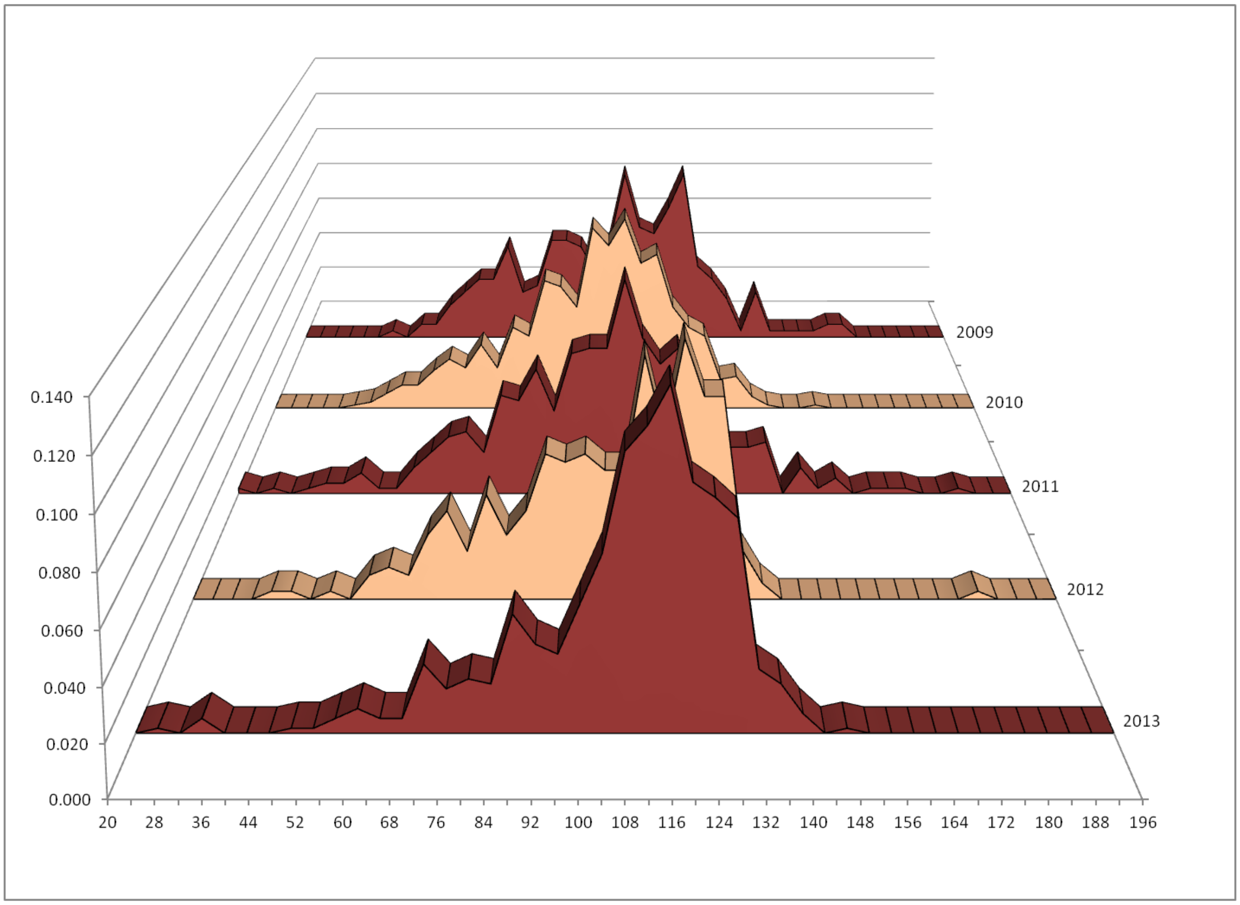


Figure 7. Length compositions of fishery catches (trawl and longline combined) for **longnose** skates in the GOA, 2009-2013.

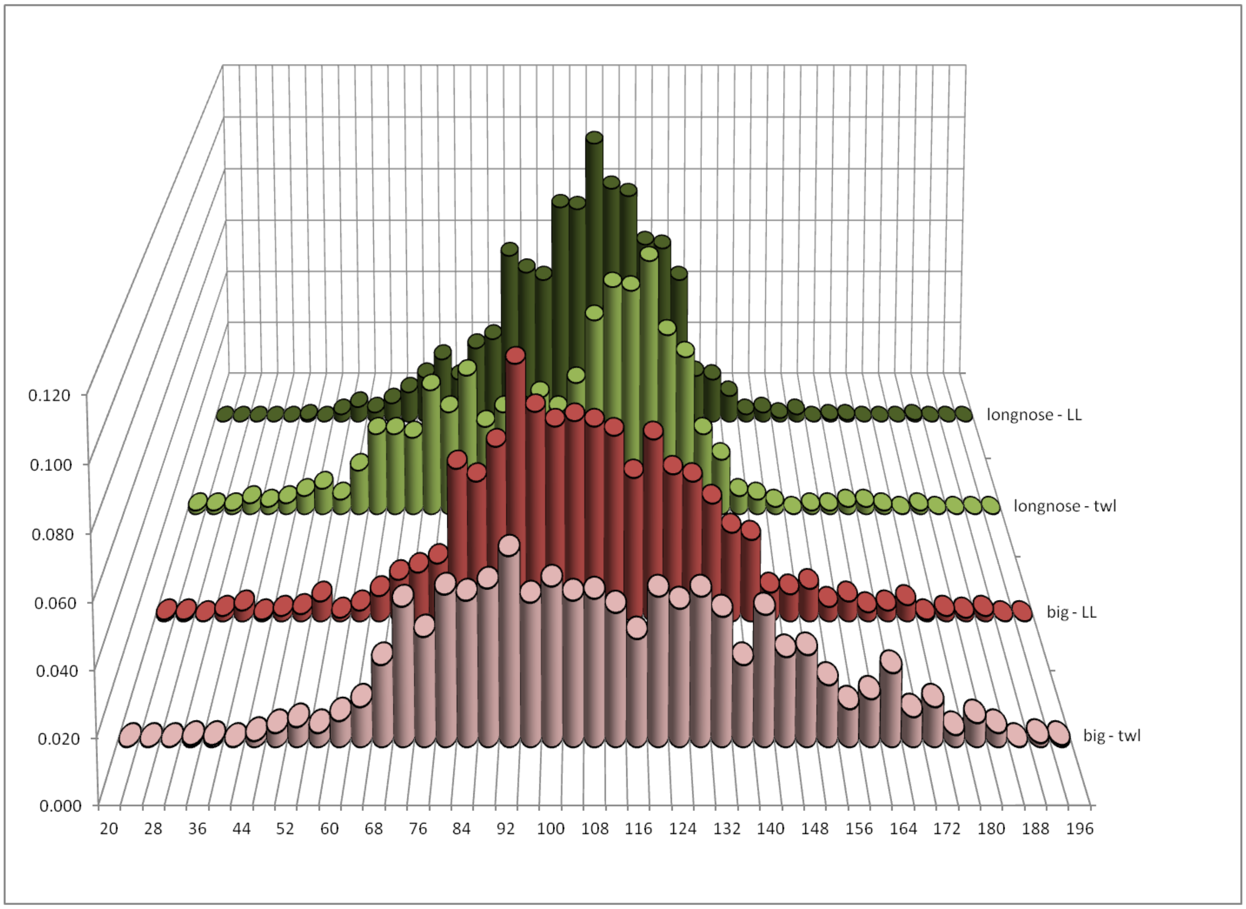


Figure 8. Comparison of trawl and longline fishery length compositions for big and longnose skates in the GOA, all years 2009-2013 combined.

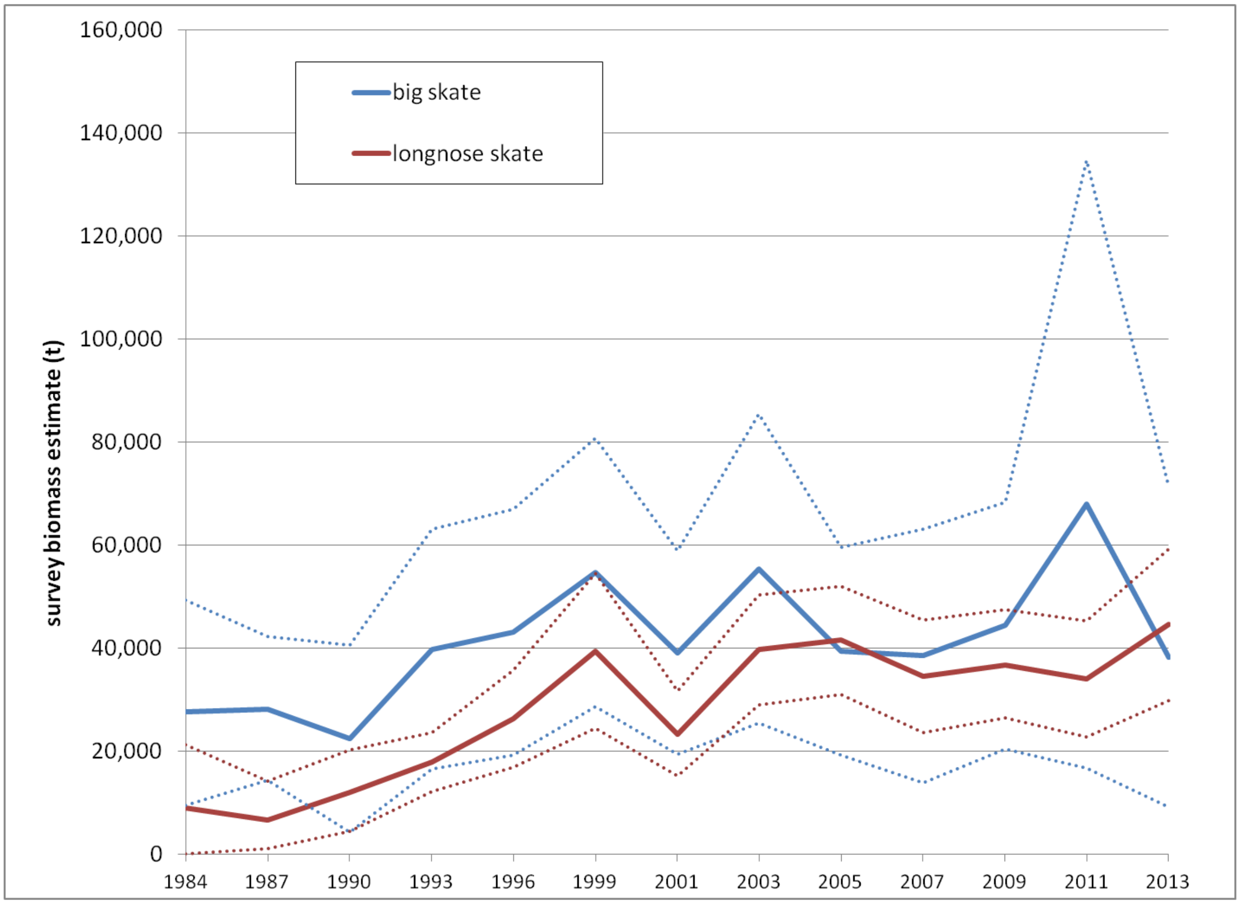
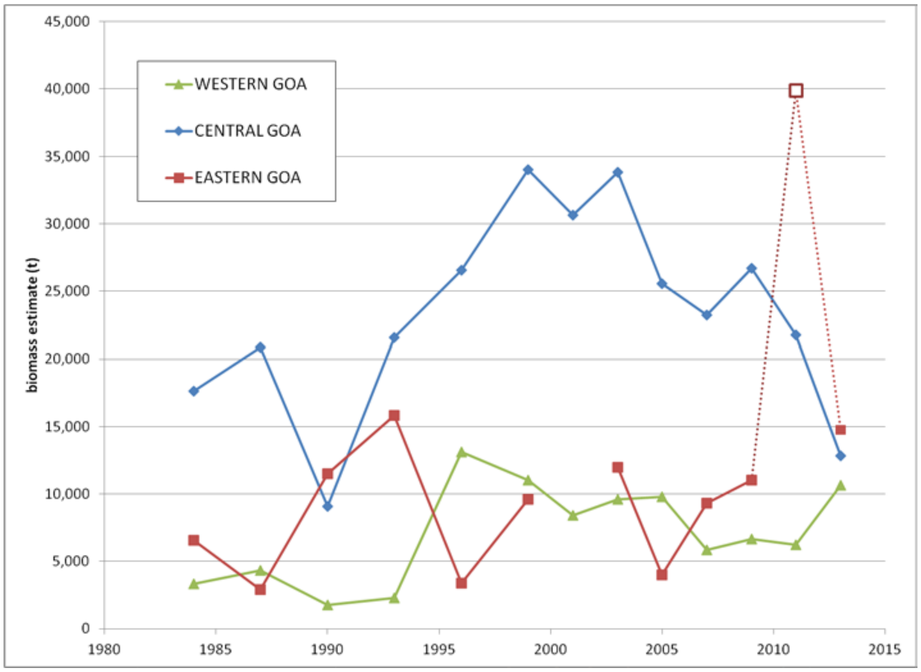


Figure 9. Biomass estimates (t) for big and longnose skates, 1984-2013, from the AFSC bottom trawl survey. Dotted lines (with corresponding colors) indicate 95% confidence intervals.



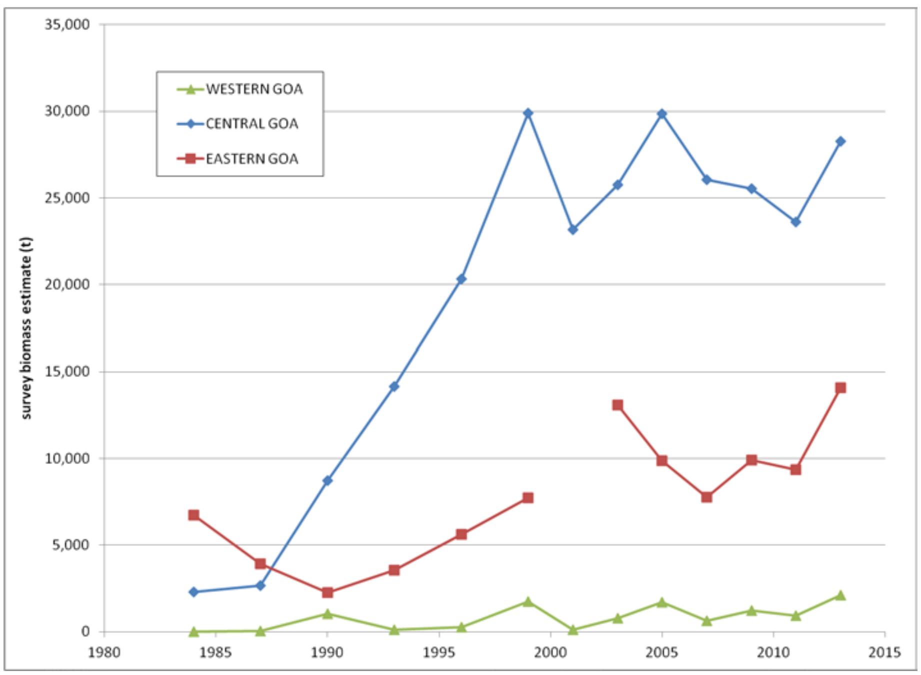


Figure 10. Biomass estimates (t) by regulatory area for big skates (top) and longnose skates (bottom), 1984-2013, from AFSC bottom trawl surveys. Confidence intervals omitted for clarity. Dotted line and open symbol in the upper plot indicate a 2011 EGOA estimate with a high CV.

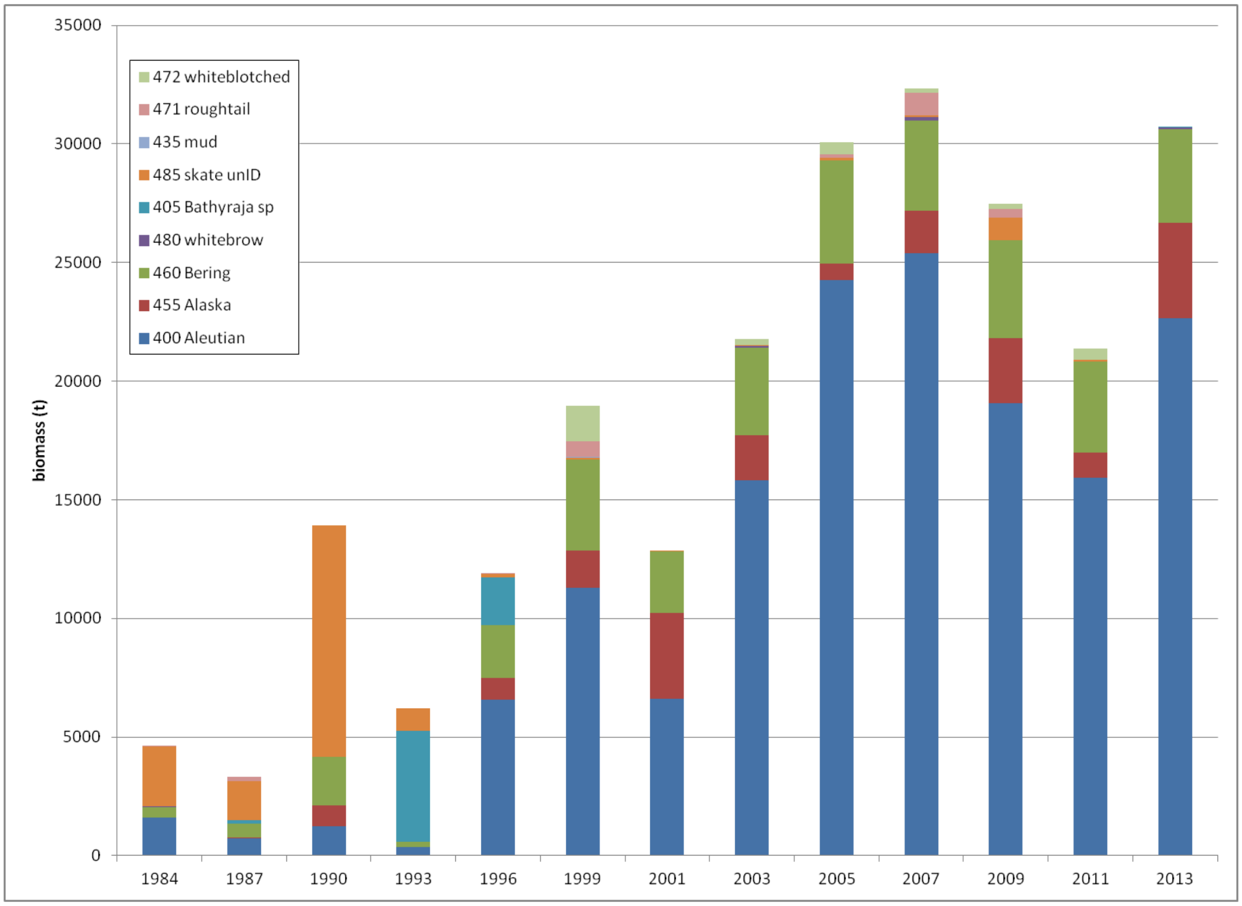


Figure 11. NMFS GOA bottom trawl survey biomass trends for *Bathyraja* skates (“other skates”), 1984-2013. The 2001 survey did not sample in the EGOA.

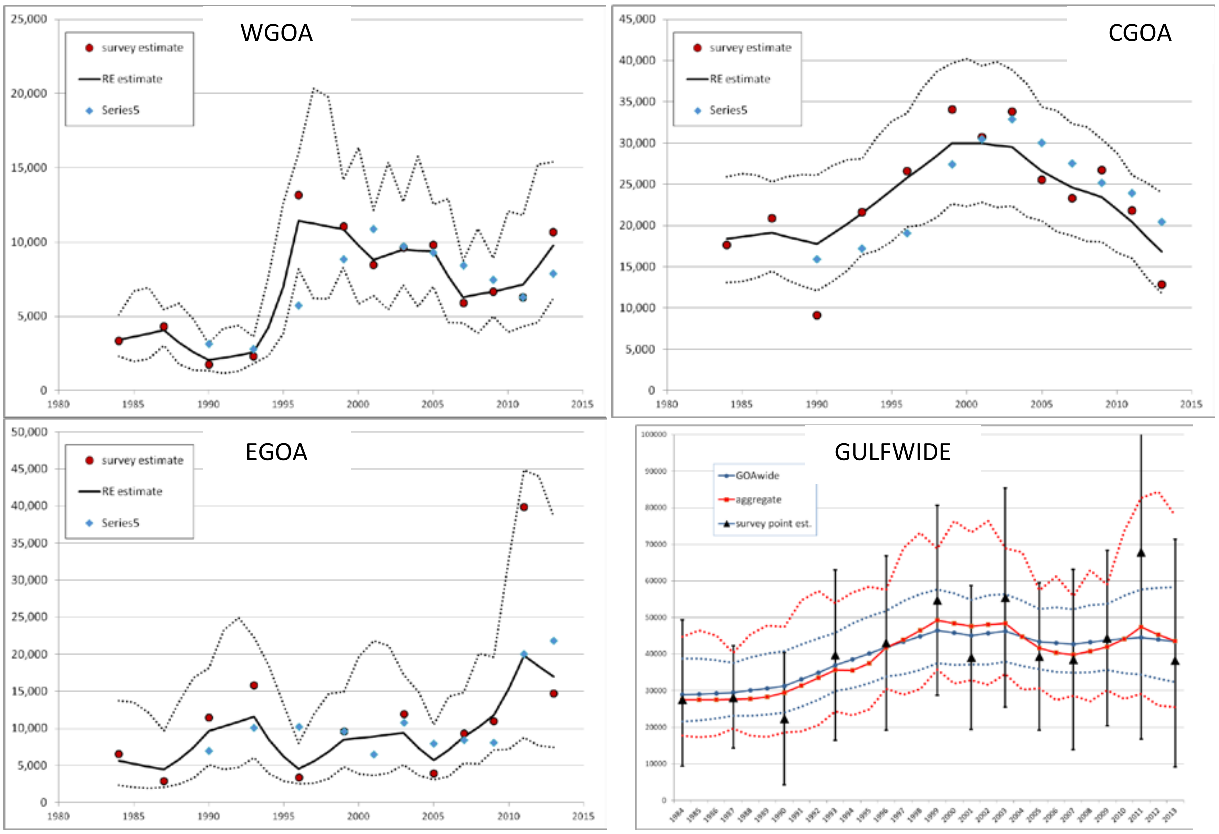


Figure 12. Estimates of **big skate** biomass from different sources. Area-specific plots include point estimates from the bottom trawl survey (red circles), 3-survey running averages (blue diamonds), and the results of the random effects (RE) model (black line); dashed black lines indicate 95% confidence interval (CI) for the RE estimate. The gulfwide plot includes estimates from a gulfwide RE model (blue line) and an aggregate of the 3 area-specific models (red line). Dashed lines indicate 95% CIs for the relevant estimates. Black triangles indicate survey point estimates with 95% CIs.

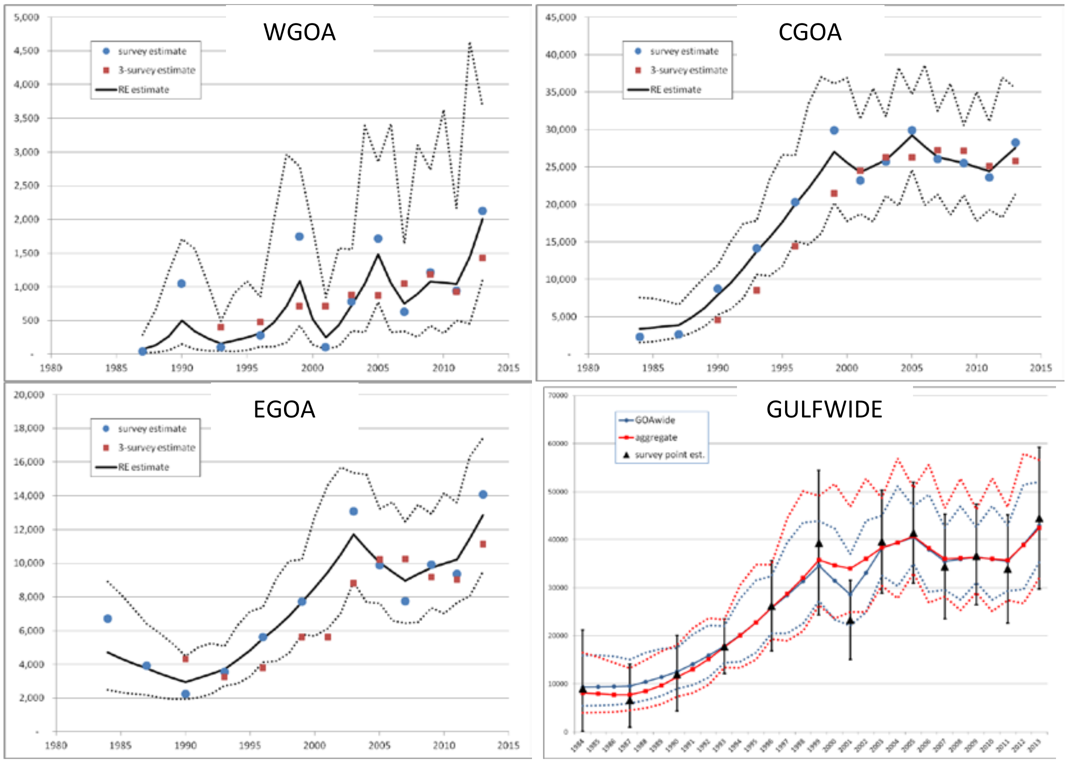


Figure 13. Estimates of **longnose skate** biomass from different sources. Area-specific plots include point estimates from the bottom trawl survey (red circles), 3-survey running averages (blue diamonds), and the results of the random effects (RE) model (black line); dashed black lines indicate 95% confidence interval (CI) for the RE estimate. The gulfwide plot includes estimates from a gulfwide RE model (blue line) and an aggregate of the 3 area-specific models (red line). Dashed lines indicate 95% CIs for the relevant estimates. Black triangles indicate survey point estimates with 95% CIs.

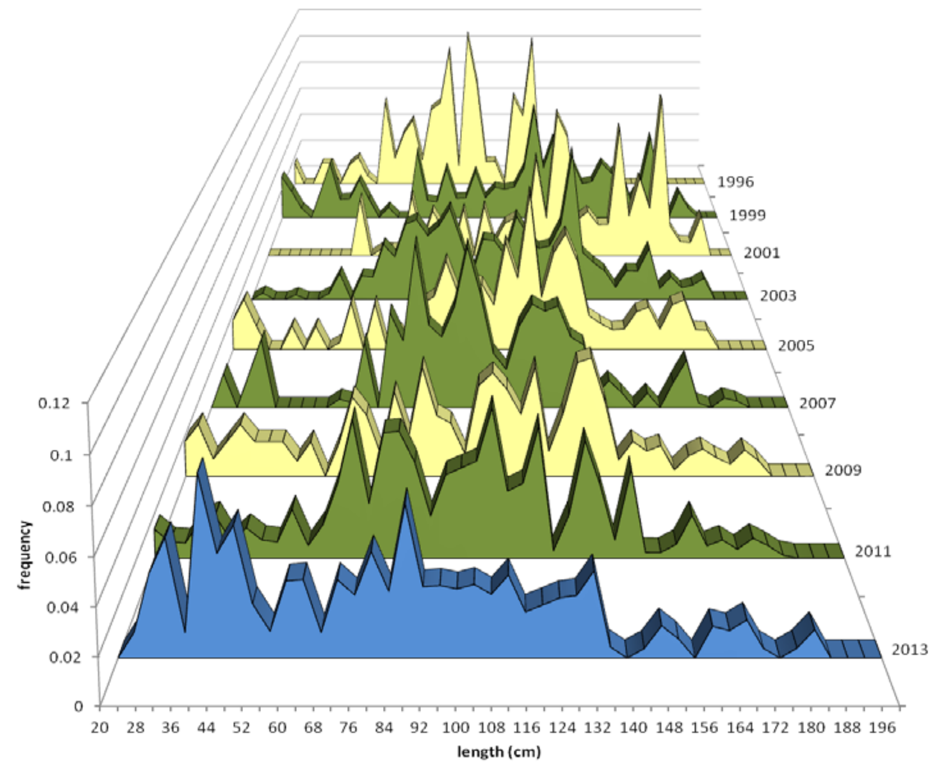


Figure 14. NMFS GOA trawl survey size composition for big skates (both sexes combined) in the entire GOA, 1996-2013. The most recent data (2013) are shown in blue.

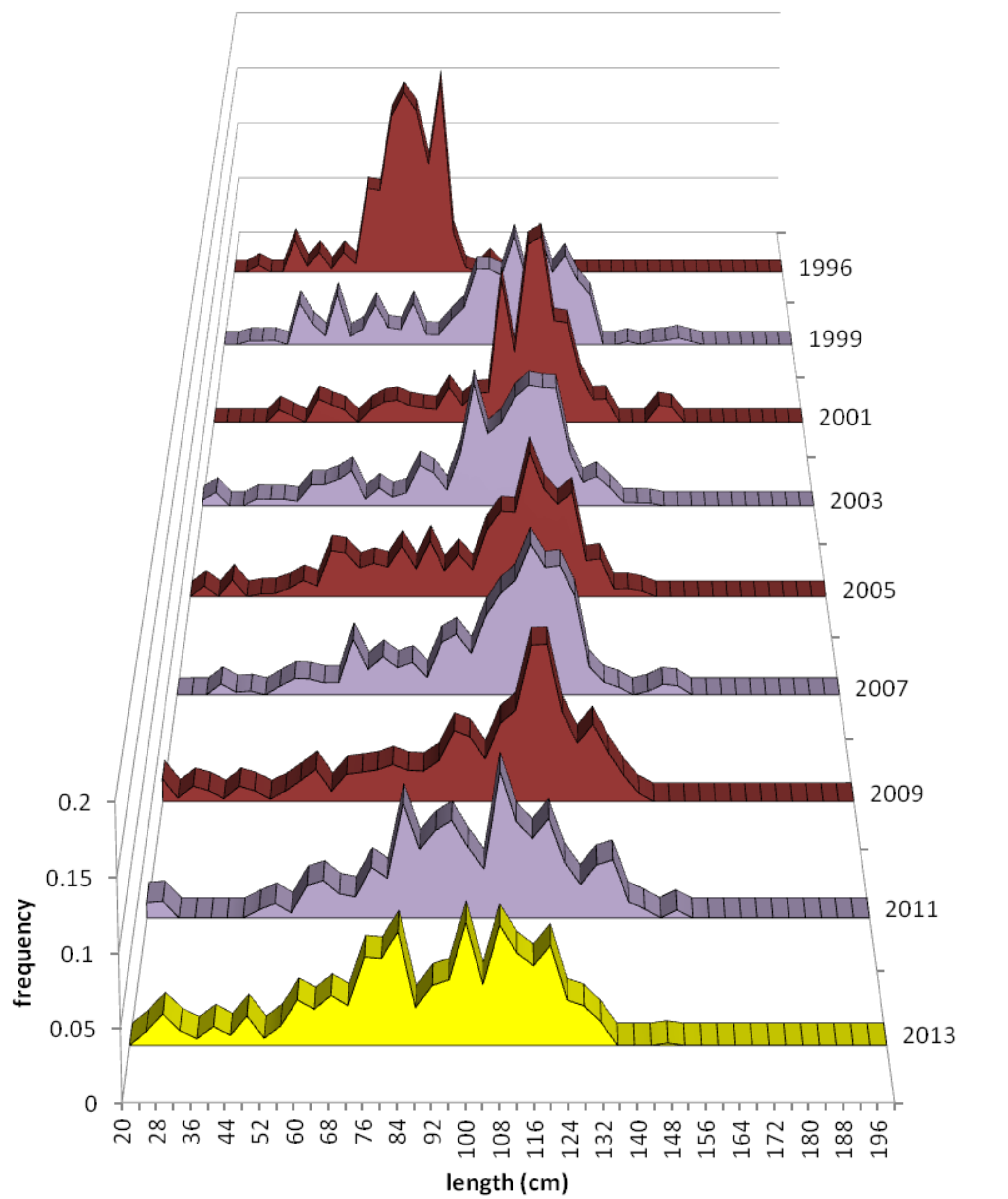


Figure 15. NMFS GOA trawl survey size composition for longnose skates (both sexes combined) in the entire GOA, 1996-2011. The most recent data (2011) are shown in yellow.

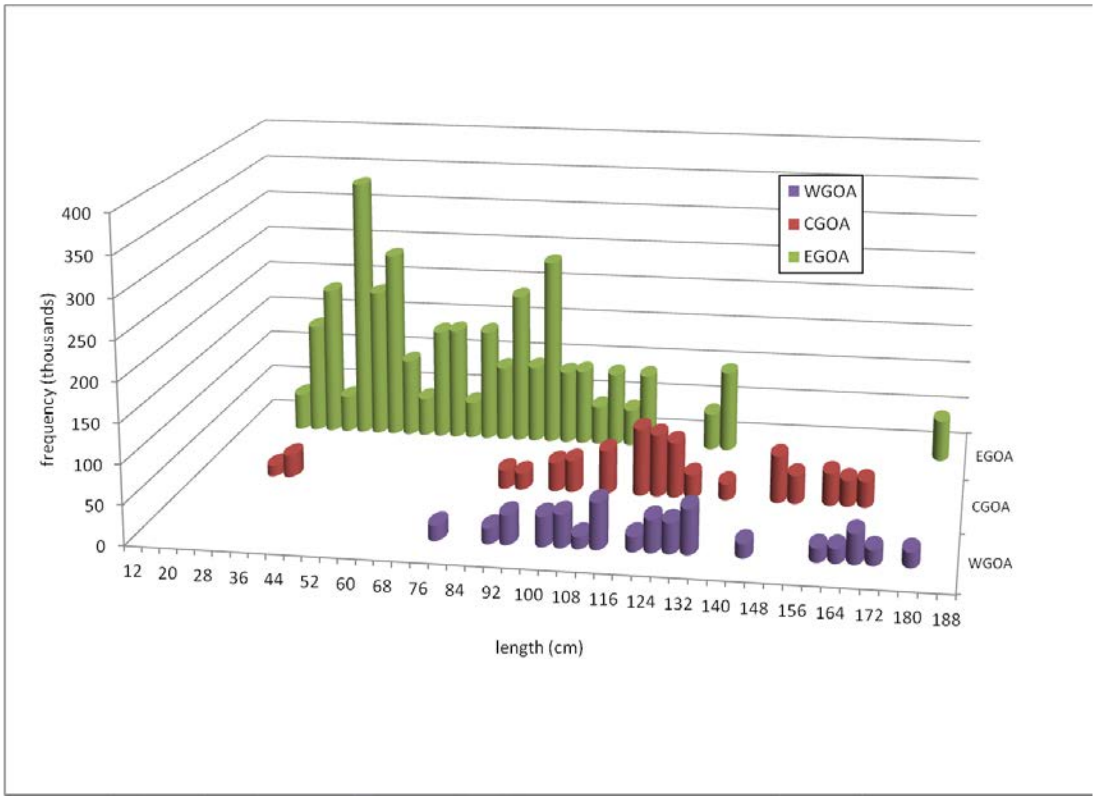


Figure 16. Big skate trawl survey length composition by regulatory area in 2013.

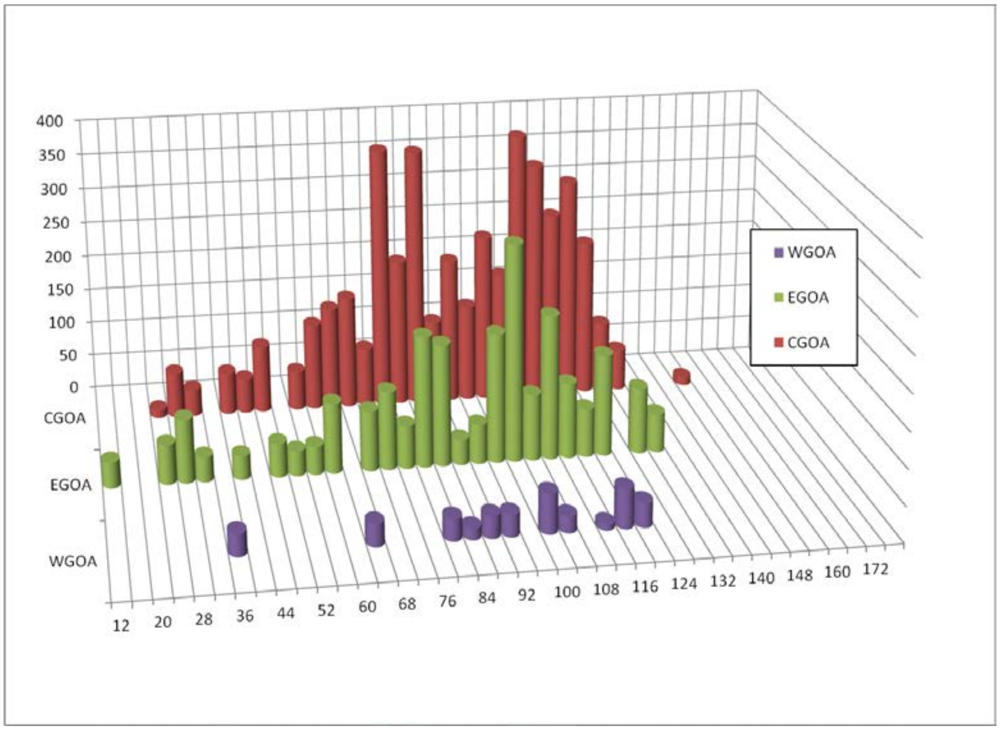


Figure 17. Longnose skate trawl survey length composition by regulatory area in 2013.

Appendix A: Summary of non-commercial catches.

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	Scallop Dredge Survey	Shelikof Acoustic Survey	Shumigans Acoustic Survey	Small-Mesh Trawl Survey	Grand Total
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

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	Grand Total
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

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	Grand Total
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

Appendix B. Stock structure report for big and longnose skates in the GOA, presented to the GOA Plan Team in September 2014.

Big skate *Beringraja binoculata* (formerly *Raja binoculata*)

SUMMARY TABLE – BIG SKATE	
HARVEST AND TRENDS	
Factor and criterion	Justification
Fishing mortality	Fishing mortality varies by area but is very high in the CGOA ($F > F_{ABC}$).
Spatial concentration of fishery relative to abundance	The fishery is very concentrated in the CGOA, particularly around Kodiak. Fishery concentrations are somewhat similar to survey CPUE patterns.
Population trends	Trends vary by area. Big skates in the CGOA and WGOA are substantially larger than those in the EGOA and may represent the mature portion of a gulfwide population. **A biomass decline in the CGOA is a major concern.**
Barriers and phenotypic characters	
Generation time	Generation time is unknown. Female $A_{50\%}$ maturity is 5 years.
Physical limitations	No physical limitations are known.
Growth differences	Data are insufficient to address this issue.
Age/size-structure (Significantly different size/age compositions)	Length composition differs by area, with smaller and immature more common in the EGOA and larger mature skates more common in the CGOA and WGOA.
Spawning time differences	Data are insufficient to address this issue.
Maturity-at-age/length differences	Data are insufficient to address this issue.
Morphometrics	Data are insufficient to address this issue.
Meristics	Data are insufficient to address this issue.
Behavior & movement	
Spawning site fidelity	Unknown, but it is likely that big skates return to highly localized nursery areas where they deposit their eggcases.
Mark-recapture data	Extensive tagging work in BC, and limited work in Alaska, indicates limited dispersal with some large-scale movements.
Natural tags	Data are insufficient to address this issue.
Genetics	
Isolation by distance	Data are insufficient to address this issue.
Dispersal distance	Data are insufficient to address this issue.
Pairwise genetic differences	Data are insufficient to address this issue.

Harvest and trends- big skate

- *Fishing mortality*: Fishing mortality differs by area (Table B-1). In the WGOA and EGOA, F is low relative to F_{ABC}. Gulfwide, F is approximately half F_{OFL}. In the CGOA, however, fishing mortality is very high and exceeded F_{ABC} every year during 2010-2013.
- *Spatial concentration of fishery*: Big skate landings are highly concentrated in the CGOA, especially in the vicinity of Kodiak (Figures B-1 and B-2). Other areas with high big skate landings are in the Shumagin Islands and Prince William Sound. These areas also tend to have the highest CPUEs in the survey data, but the areas of concentration in the fishery do not completely match the pattern of survey CPUEs.
- *Population trends*: Population trends differ substantially among regions (Figure B-3). Biomass estimates in the EGOA are more variable than in the other areas. This is consistent with length composition data (described below and in Figure B-4) that suggest younger big skates are predominantly found in the EGOA, and then move to the CGOA and WGOA as they grow. Thus the variability in EGOA biomass may represent a recruitment signal. In contrast, biomass trends in the COGA and WGOA are less variable and may indicate a more temporally stable aggregation of older skates. There has been a steady decline in CGOA big skate biomass since 2003, which is a major concern for this stock.

Barriers and phenotypic characters- big skate

- *Generation time*: Generation time is unknown for big skates, but age at 50% maturity ($A_{50\%}$) for females is 4.8 years. Generation time is probably not excessively long for big skates.
- *Physical limitations*: There do not appear to be any physical barriers to movements of big skates.
- *Age/size structure*: Length compositions are different among the areas (Figure B-4). Big skates in the EGOA are smaller than in the other areas and are mostly immature. In contrast, skates in the CGOA and WGOA are larger and mostly mature. With some variability this pattern among areas is consistent over time (Figure B-5), with the highest mean lengths in the WGOA. These patterns suggest a gulfwide population of big skates, with large-scale ontogenetic movements. Large-scale ontogenetic migration has also been observed in Alaska skate *Bathyraja parmifera* in the eastern Bering Sea (Ormseth 2012).
- The other attributes in this section (growth differences, spawn timing, maturity differences, morphometrics, and meristics) cannot be addressed due to a lack of data.

Behavior and movement- big skate

- *Spawning site fidelity*: Fidelity to spawning sites has not been studied in big skates. In general, skates appear to deposit their embryos (protected by eggcases) in small, highly localized nursery areas (Hoff 2007). Nursery areas of other skate species in the Bering Sea have very high densities of eggcases, and skates appear to use the same areas for many years.
- *Mark-recapture data*: Extensive mark-recapture studies of big skates in British Columbia waters suggest that skates show limited dispersal from fairly small areas (King and McFarlane 2010). A small percentage (1.5%) of big skates made large-scale movements (~1,000 km). Pop-up satellite tags are currently being used to study movements of big skates in the GOA (Thomas Ferrugia, UAF, pers. comm. 2014). Preliminary results

indicate that some big skates had very limited movements (~10 km) but that several moved over 100 km.

- No data were available regarding natural tags.

Genetics – big skate

- No genetics data are available for big skates.

Summary and conclusions – big skate

Although the data are insufficient to make any firm conclusion regarding stock structure of big skates in the GOA, the available information is consistent with a gulfwide population. Small and immature skates are mainly found in the EGOA, while the CGOA and WGOA have mostly mature skates. This pattern suggests a gulfwide population with ontogenetic movement among areas. The abundance patterns for big skates are consistent with this interpretation: higher variability in the GOA may indicate a recruitment signal, while the lower variability in the CGOA and WGOA is consistent with a group of older skates with less annual variation in abundance. In contrast, the limited movement of big skates in British Columbia waters led researchers there to conclude that separate stocks existed even across small spatial scales (King and McFarlane 2010) and that separate management was warranted.

In sum, this analysis suggests that current management practices with a gulfwide OFL is appropriate for big skates in the GOA management area. However the differences in size, and their implication for the spatial distribution of immature and mature skates, also support the use of area-specific ABCs to limit catches in each area. **The decline of big skate biomass in the CGOA, where F has exceeded F_{ABC} every year during 2010-2013, underlines this point and is of major concern.**

Table 1. Catch statistics for big skates, 2009-2013. "EGOA_1" includes only areas 640 & 650. "EGOA_2" includes areas 640 and 650 as well as areas 649 and 659 (inside waters). Colored shading indicates year/area combinations where F/F_{ABC} exceeded 1.

		2009	2010	2011	2012	2013
WGOA	catch	79	148	110	66	121
	ABC	632	598	598	469	469
	F/F_{ABC}	0.13	0.25	0.18	0.14	0.26
CGOA	catch	1,903	2,215	2,105	1,894	2,303
	ABC	2,065	2,049	2,049	1,793	1,793
	F/F_{ABC}	0.92	1.08	1.03	1.06	1.28
EGOA_1	catch	100	149	90	38	79
	ABC	633	681	681	1,505	1,505
	F/F_{ABC} _1	0.16	0.22	0.13	0.03	0.05
EGOA_2	catch	137	179	134	61	221
	ABC	633	681	681	1,505	1,505
	F/F_{ABC} _2	0.22	0.26	0.20	0.04	0.15
gulfwide	catch	2,119	2,542	2,350	2,021	2,645
	OFL	4,439	4,438	4,438	5,023	5,023
	F/F_{OFL}	0.48	0.57	0.53	0.40	0.53

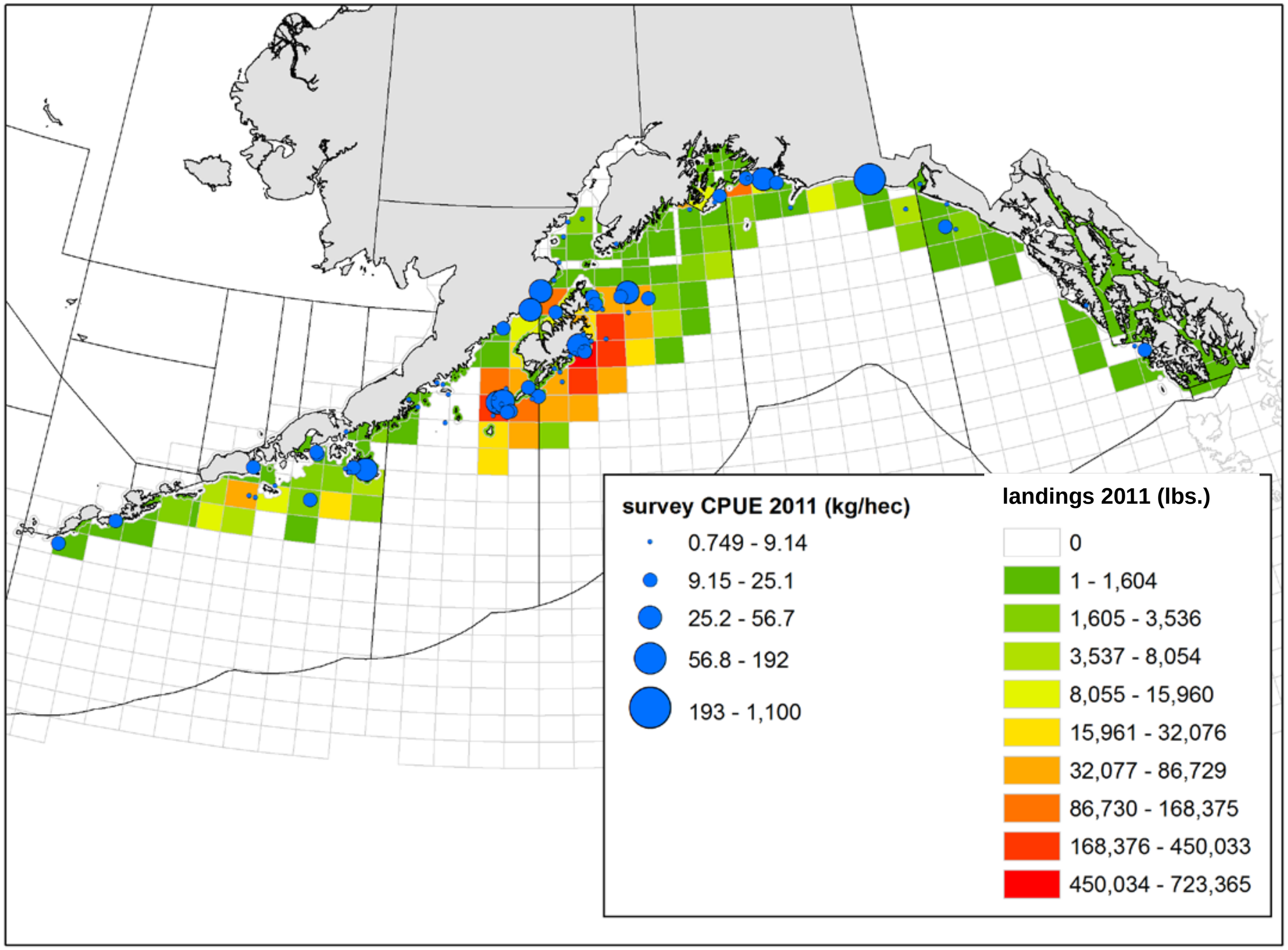


Figure B-1. Bottom trawl survey CPUEs and commercial landings of big skates in the GOA during 2011. Landings data are from ADFG fish tickets and are aggregated by ADFG statistical areas.

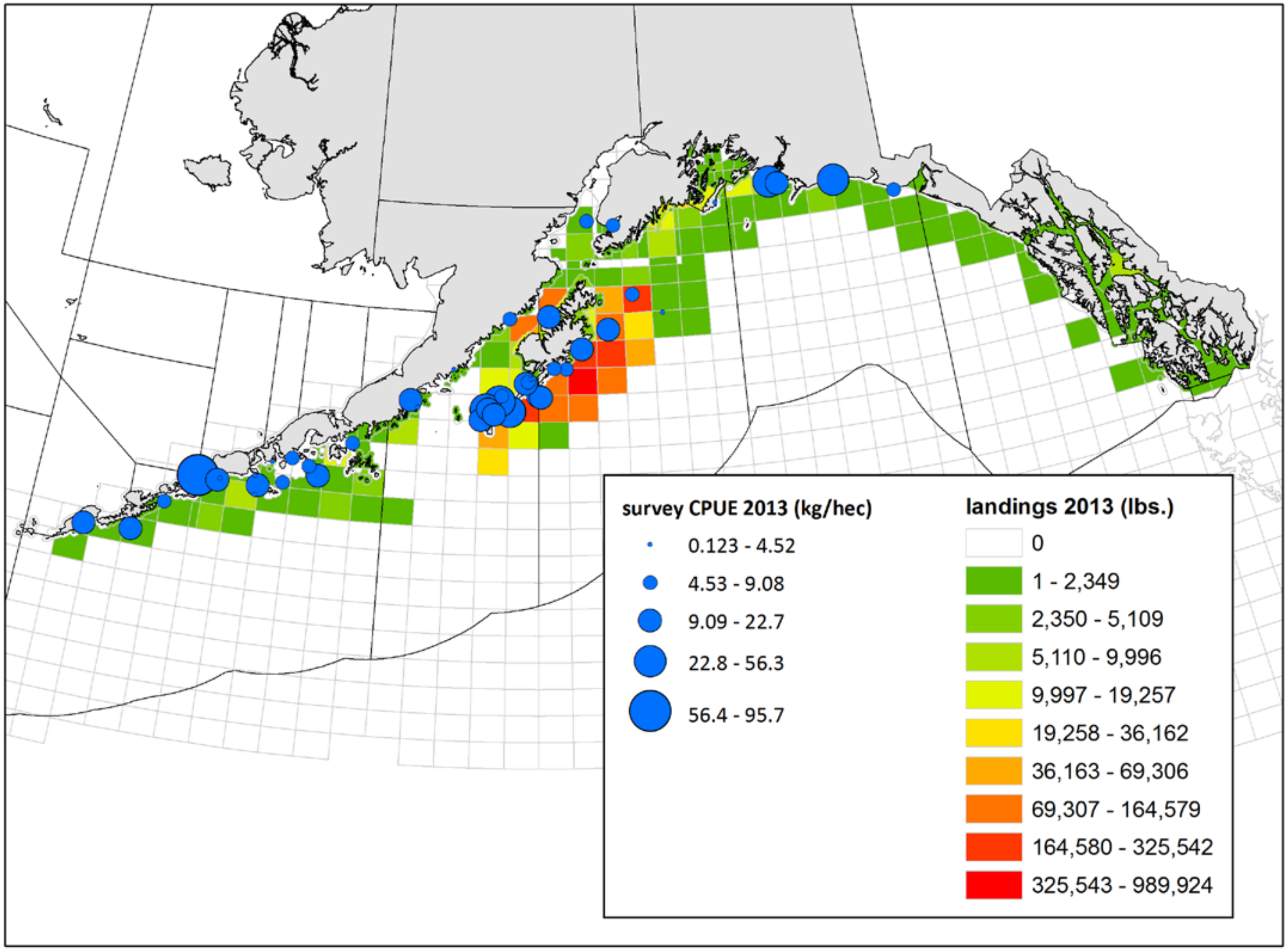


Figure B-2. Bottom trawl survey CPUEs and commercial landings of big skates in the GOA during 2013. Landings data are from ADFG fish tickets and are aggregated by ADFG statistical areas.

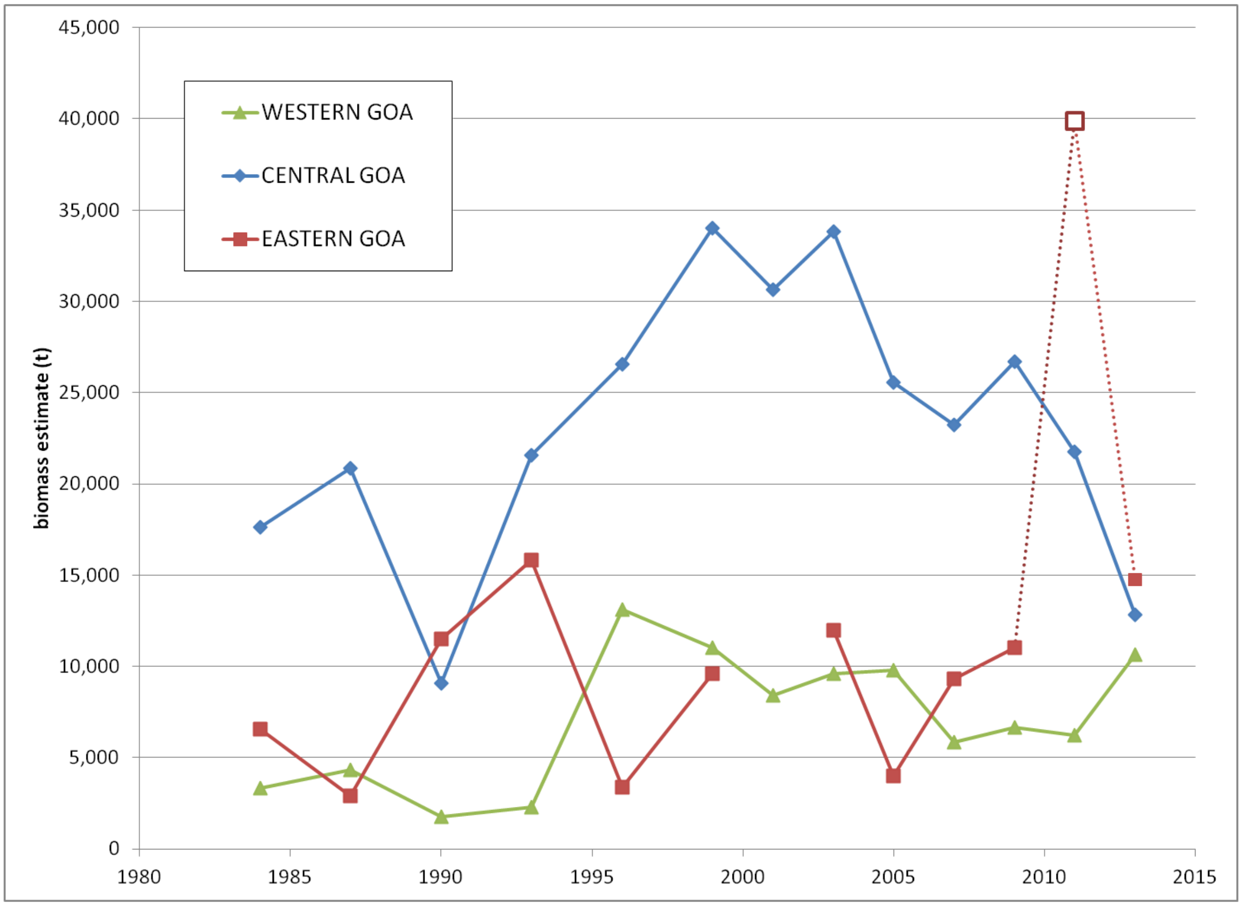


Figure B-3. Time series of survey biomass estimates for big skates in the 3 regulatory areas of the GOA, 1984-2013. Open square and dashed lines in the EGOA dataset indicate the 2011 biomass estimate that was highly influenced by a single vary large tow of big skates and had a much higher CV than the other estimates.

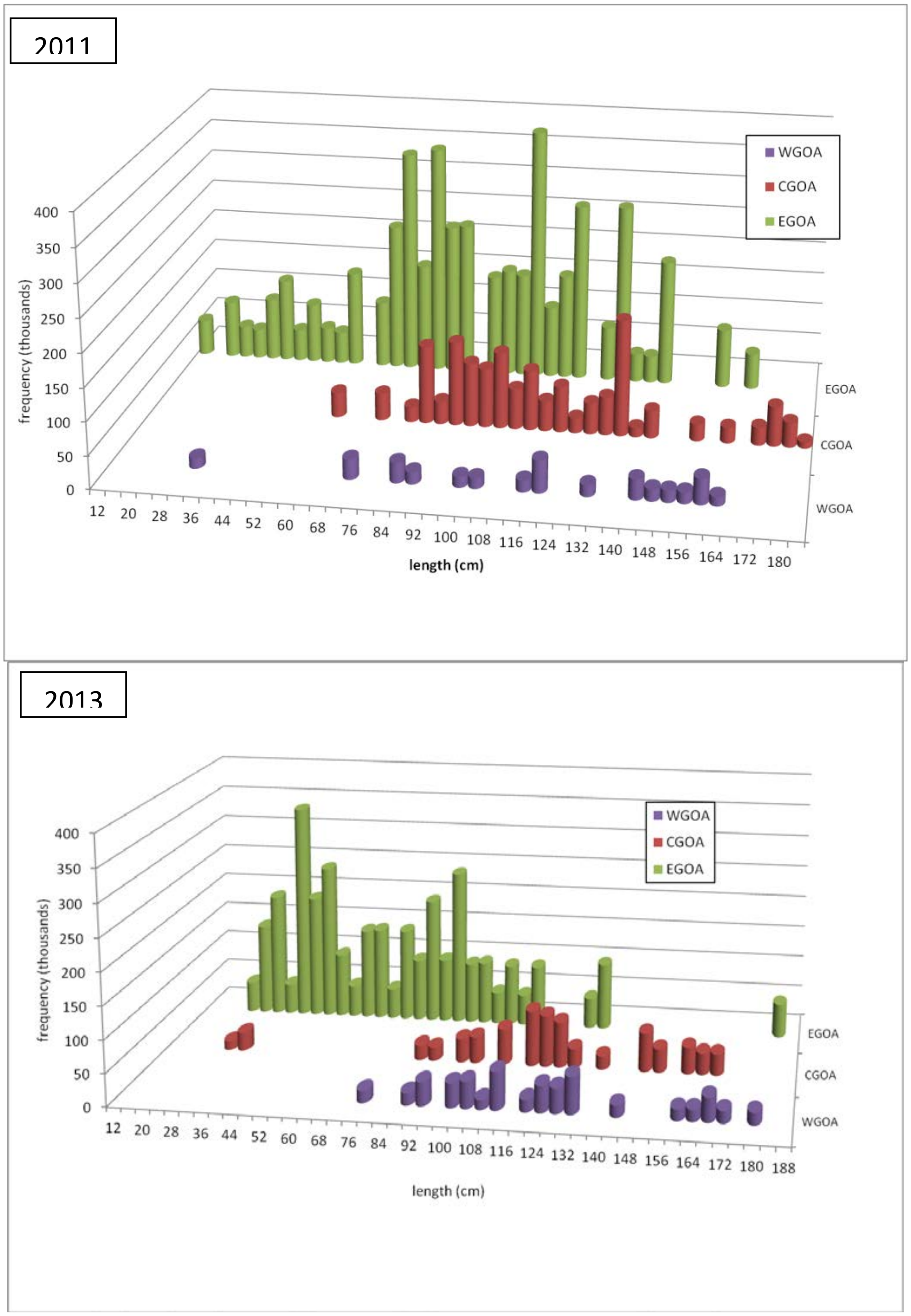


Figure B-4. Trawl survey length compositions of big skates in the GOA, by area, in 2011 (top panel) and 2013 (bottom panel).

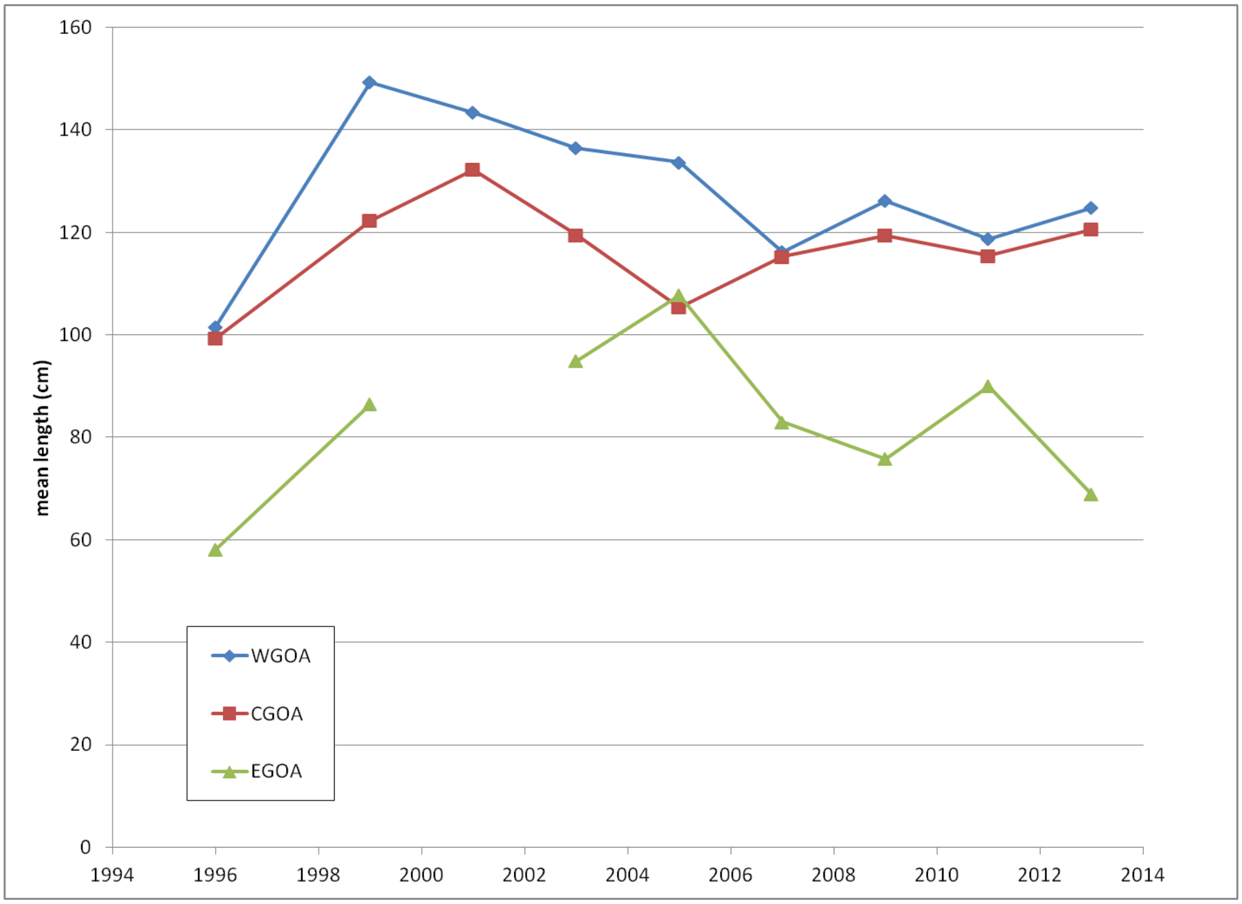


Figure B-5. Annual mean lengths of big skates in the three GOA regulatory areas, 1996-2013.

Longnose skate *Raja rhina*

SUMMARY TABLE – LONGNOSE SKATE	
HARVEST AND TRENDS	
Factor and criterion	Justification
Fishing mortality	Differs by area. $F > F_{ABC}$ in some years in the WGOA, and F may be greater than F_{ABC} in the EGOA depending on which catch data are included.
Spatial concentration of fishery relative to abundance	The fishery is highly concentrated, especially around Kodiak Island. The fishery is more concentrated than are the CPUEs in the survey.
Population trends	Population trends vary substantially among areas. Skate abundance has increased since 1990 in all areas, but the CGOA increase has been much greater than the other areas.
Barriers and phenotypic characters	
Generation time	Unknown, but female $A_{50\%}$ is 12.3 years.
Physical limitations	No physical limitations are known.
Growth differences	Data are insufficient to address this issue.
Age/size-structure	Size structure varies somewhat among the areas. Trends in mean size are fairly similar
Spawning time differences	Data are insufficient to address this issue.
Maturity-at-age/length differences	Data are insufficient to address this issue.
Morphometrics	Data are insufficient to address this issue.
Meristics	Data are insufficient to address this issue.
Behavior & movement	
Spawning site fidelity	Unknown, but it is likely that longnose skates return to highly localized nursery areas where they deposit their eggcases.
Mark-recapture data	Data are insufficient to address this issue.
Natural tags	Data are insufficient to address this issue.
Genetics	
Isolation by distance	Data are insufficient to address this issue.
Dispersal distance	Data are insufficient to address this issue.
Pairwise genetic differences	Data are insufficient to address this issue.

Harvest and trends- longnose skate

- *Fishing mortality*: Fishing mortality for longnose skates varies by area, and results vary depending on whether catch data from inside waters (areas 649 & 659) are included (Table L-1). In the CGOA, F has been approximately ½ of F_{ABC} over the last 5 years. In the WGOA, F has exceeded F_{ABC} in 3 out of the last 5 years. In the EGOA, F was relatively low during 2009-2012 but increased in 2013. When inside waters are included, F was 1.25 times F_{ABC} in 2013. These results are likely due to an increase in catch reporting rather than an increase in the actual F.
- *Spatial concentration of fishery*: The fishery is highly concentrated in several areas (Figures L-1 & L-2). The biggest area of concentration is around Kodiak Island. Landings patterns vary by year but appear to be more highly concentrated than the survey CPUE.
- *Population trends*: The abundance of longnose skates varies among the areas, as does the trend in abundance (Figure L-3). Longnose skates have increased in all areas since 1990, with most of this increase occurring before 2000. The increase has been much greater in the CGOA than in the other two areas, and the WGOA has had the lowest rate of increase.

Barriers and phenotypic characters- longnose skate

- *Generation time*: Generation time is not known for longnose skates. However $A_{50\%}$ for female and male longnose skates is 12.3 and 9 years, respectively. This suggests that generation time is relatively long for this species.
- *Physical limitations*: There are no apparent physical barriers to dispersal for this species in the GOA.
- *Age/size structure*: Length compositions vary somewhat among the areas (Figure L-4). Unlike big skates, however, these differences are minor and do not appear to represent separate segments of a gulfwide population. Mean size has varied over time in each area, and the trends in mean size are fairly similar among areas (Figure L-5).
- The other attributes in this section (growth differences, spawn timing, maturity differences, morphometrics, and meristics) cannot be addressed due to a lack of data.

Behavior and movement- longnose skate

- *Spawning site fidelity*: Fidelity to spawning sites has not been studied in longnose skates. In general, skates appear to deposit their embryos (protected by eggcases) in small, highly localized nursery areas (Hoff 2007). Nursery areas of other skate species in the Bering Sea have very high densities of eggcases, and skates appear to return to the same area for many years.
- No mark-recapture or natural-tag data exist for longnose skates.

Genetics- longnose skate

- No genetics data are available for big skates.

Summary and conclusions- longnose skate

In contrast to big skates, the data for longnose are not indicative of a gulfwide longnose skate population. Although the data are insufficient to conclude that separate longnose populations exist in the GOA, the different abundance trends and the differences in size structure are consistent with some degree of separation of stocks. Investigation of stock structure in GOA longnose skates is a priority for research.

In sum, the use of area-specific ABCs for skate management is warranted by the available data. If better evidence of discrete longnose stocks become available it may also be appropriate to define area-specific OFLs for this species. The problem of unknown stock structure is exacerbated in longnose skates due to the high concentration of fishery removals and their vulnerable life history strategy.

Table L-1. Catch statistics for longnose skates, 2009-2013. "EGOA_1" includes only areas 640 & 650. "EGOA_2" includes areas 640 and 650 as well as areas 649 and 659 (inside waters). Colored shading indicate area/year combinations where F/F_{ABC} was greater than 1.

		2009	2010	2011	2012	2013
WGOA	catch	79	106	71	37	90
	ABC	78	81	81	70	70
	F/F_{ABC}	1.02	1.31	0.88	0.52	1.28
CGOA	catch	1,096	851	892	786	1,260
	ABC	2041	2009	2009	1879	1879
	F/F_{ABC}	0.54	0.42	0.44	0.42	0.67
EGOA_1	catch	244	132	68	79	426
	ABC	768	762	762	676	676
	F/F_{ABC}_1	0.32	0.17	0.09	0.12	0.63
EGOA_2	catch	320	198	118	119	846
	ABC	768	762	762	676	676
	F/F_{ABC}_2	0.42	0.26	0.16	0.18	1.25
gulfwide	catch	1,495	1,155	1,082	941	2,195
	OFL	3,849	3,803	3,803	3,500	3,500
	F/F_{OFL}	0.39	0.30	0.28	0.27	0.63

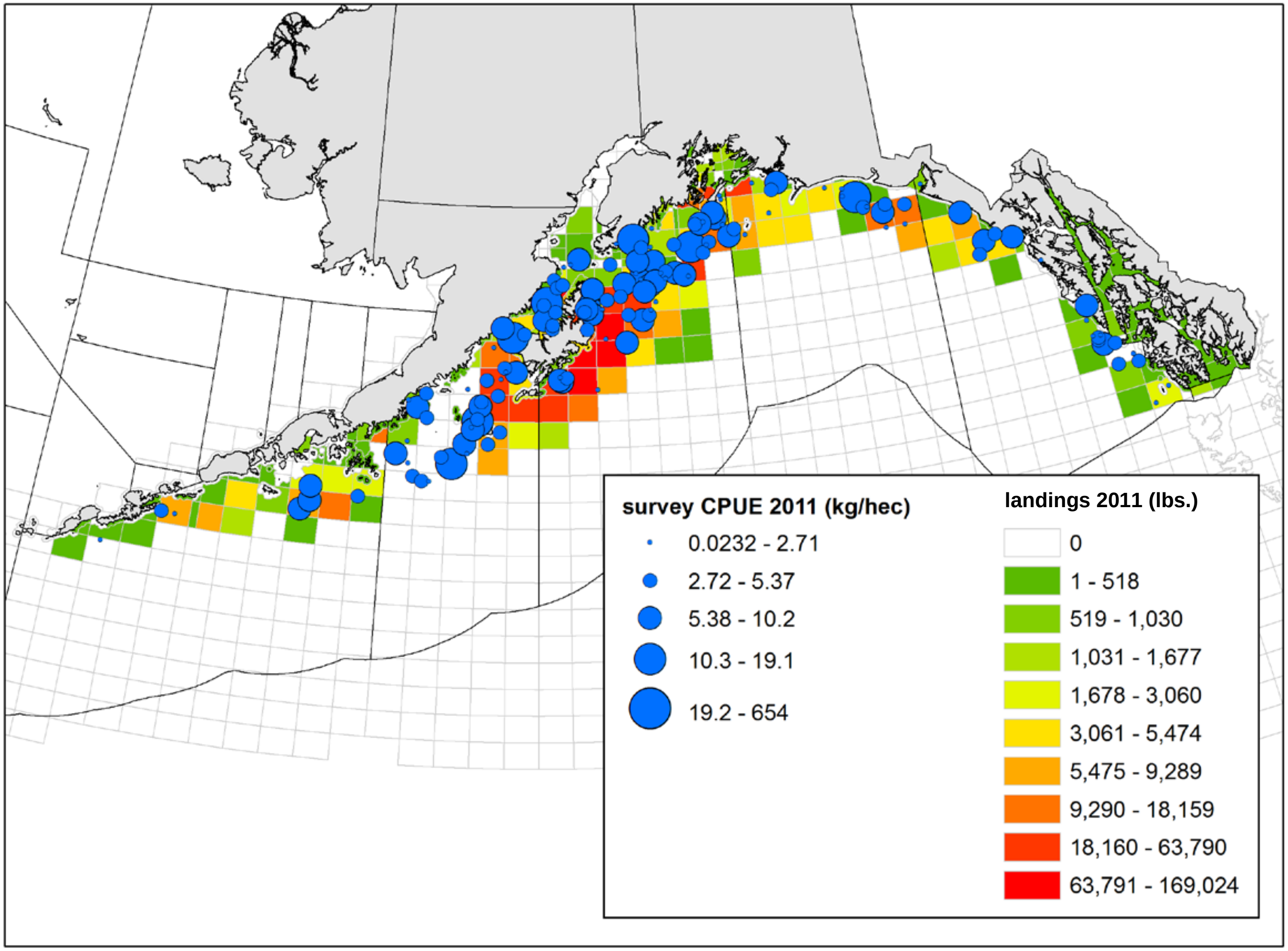


Figure L-1. Bottom trawl survey CPUEs and commercial landings of longnose skates in the GOA during 2011. Landings data are from ADFG fish tickets and are aggregated by ADFG statistical areas.

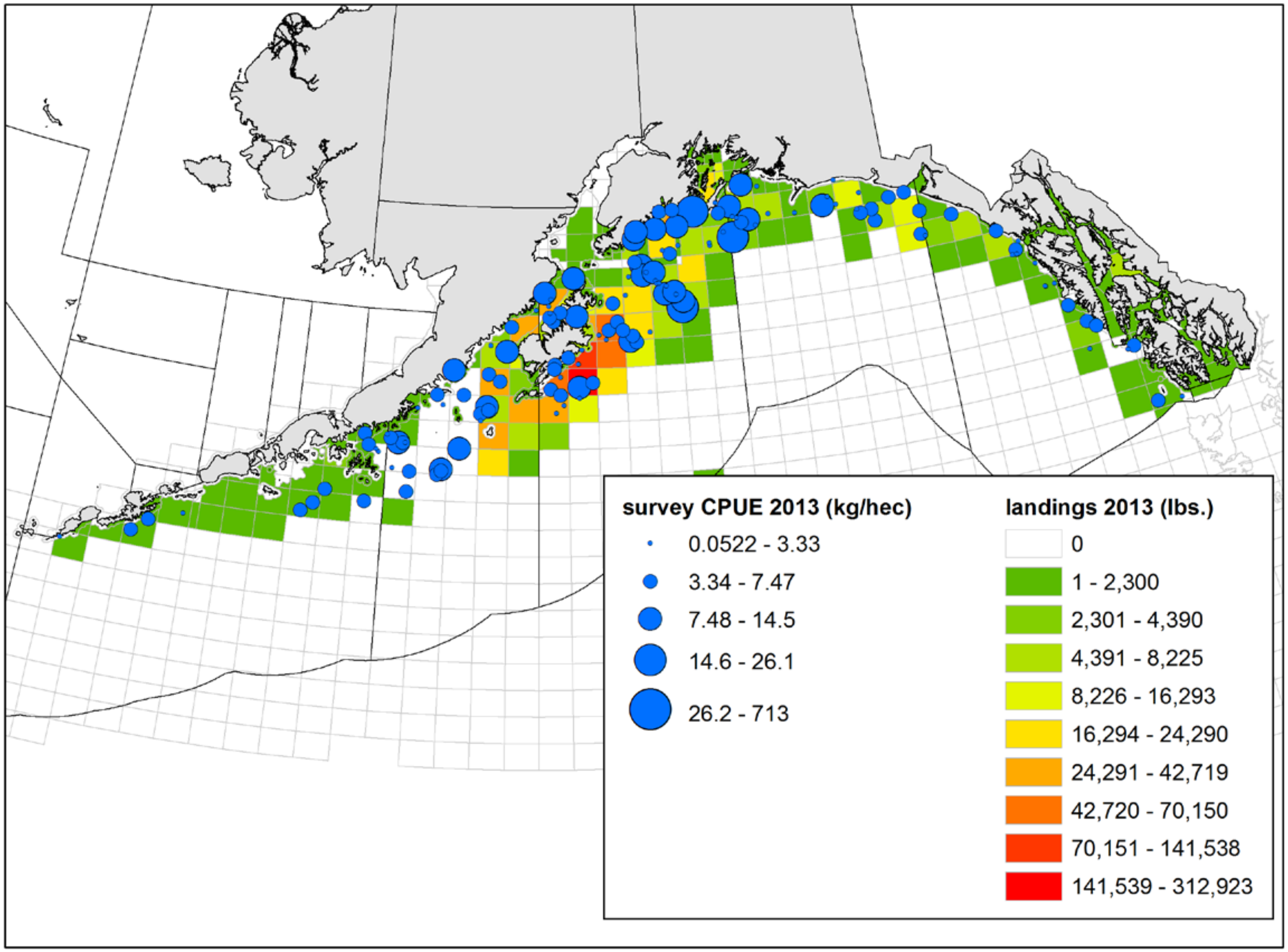


Figure L-2. Bottom trawl survey CPUEs and commercial landings of longnose skates in the GOA during 2013. Landings data are from ADFG fish tickets and are aggregated by ADFG statistical areas.

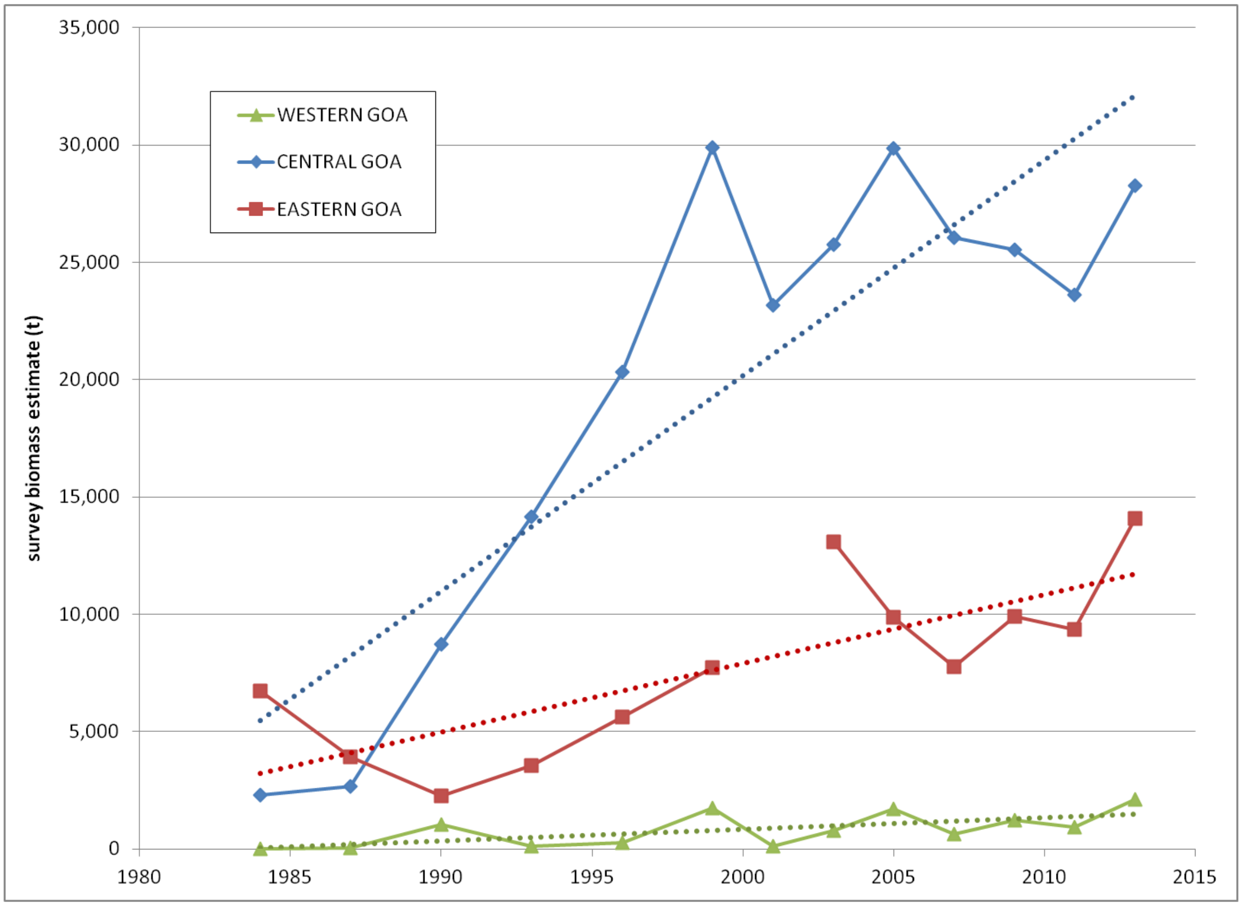


Figure L-3. Time series of survey biomass estimates for longnose skates in the 3 regulatory areas of the GOA, 1984-2013.

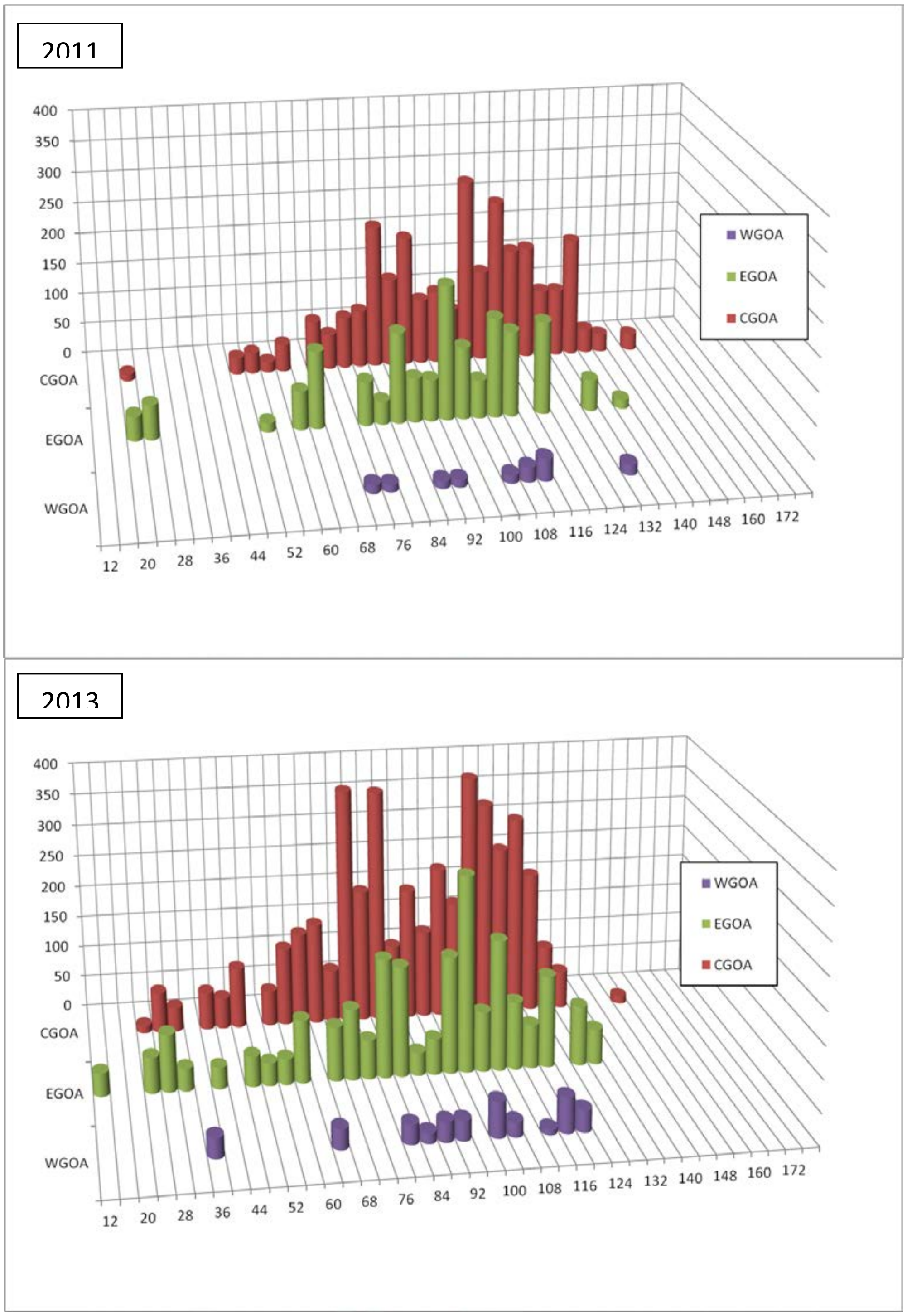


Figure L-4. Trawl survey length compositions of longnose skates in the GOA, by area, in 2011 (top panel) and 2013 (bottom panel).

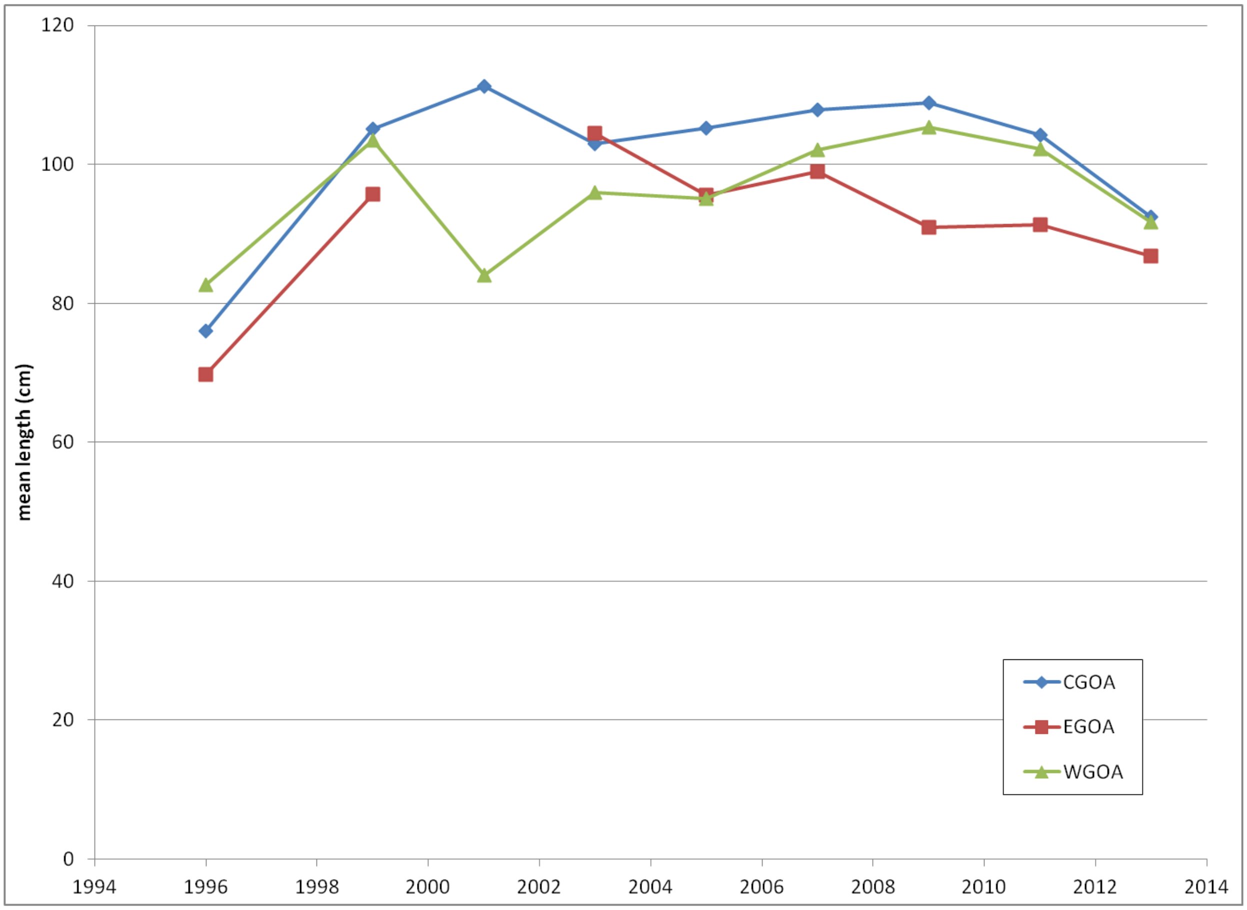


Figure L-5. Annual mean lengths of longnose skates in the three GOA regulatory areas, 1996-2013.

Literature Cited

Hoff GR (2007) Reproduction of the Alaska skate (*Bathyraja parmifera*) with regard to nursery sites, embryo development and predation. PhD dissertation, University of Washington, Seattle.

King JR and GA McFarlane (2010) Movement patterns and growth estimates of big skate (*Raja binoculata*) based on tag-recapture data. Fisheries Research 101: 50-59

Ormseth O (2012) Bering Sea and Aleutian Islands skates. IN: Stock assessment and fishery evaluation report for the groundfish resources of the Bering Sea/ Aleutian Islands regions. North Pacific Fishery Management Council, Anchorage, AK 99501