# Assessment of the Grenadier Stock Complex in the Gulf of Alaska, Eastern Bering Sea, and Aleutian Islands

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November 2014

## Executive Summary

The Secretary of Commerce approved Amendments 100/91 on August 6, which added the grenadier complex into both FMPs as Ecosystem Components. Under this rule, they are not allowed to be targeted but there is an 8% Maximum Retainable Allowance (MRA) (Federal Register, Proposed Rules, Vol. 79, No. 93). The final rule will publish before the end of the year and so it may be effective for the start of the 2015 fishing year.

As an Ecosystem Component, a stock assessment is not required and there is no ABC or OFL. A full unofficial assessment report was prepared for grenadiers in even years since 2006, even though they were "nonspecified". For 2015, we are presenting an abbreviated SAFE report for the BSAI and GOA combined for the purpose of tracking trends in abundance. This content of future reports is still being evaluated since a SAFE report is not required. This report contains a time series of catch and abundance estimates and unofficial ABC and OFL values based on Tier 5 calculations. These values are not used for management or for determining if overfishing is occurring for Ecosystem Component species/complexes. There is no definition of overfishing for an Ecosystem Component.

## Summary of Changes in Assessment Inputs

*Changes in the input data:* New data inputs include: 1) updated catch data for 2003-2014; 2) updated 2000-2014 Aleutian Island (AI) biomass from 1-1,000 m using the estimation method presented in the 2012 SAFE; 3) NMFS longline survey results for 2013 and 2014; 4) updated GOA biomass using a random effects model. There was no EBS slope trawl survey in 2014.

*Changes in assessment methodology:* This year we use a random effects model (a similar method, a Kalman filter, was presented in the 2012 SAFE report (Rodgveller et al. 2012)), that utilizes trawl survey data from 1984-2013 to estimate the exploitable biomass in 2013. Since there was no trawl survey in the GOA in 2014, the estimate for 2013 is used as the most recent value of exploitable biomass.

## Summary of Results

For 2015, the maximum allowable ABC for the BSAI is 75,274 t and for the GOA is 30,691 t. This ABC is a 12% increase for the BSAI and a 12% decrease for the GOA. The corresponding reference values for grenadier are summarized in the following tables, with the recommended ABC and OFL values in bold. Overfishing is not occurring in either the BSAI or GOA.

## Gulf of Alaska Grenadiers

| Quantity | As estimated or specified *last* year for[a]: 2014 | 2015 | As estimated or recommended *this* year for: 2015 | 2016 |
|---|---|---|---|---|
| *M* (natural mortality) | 0.078 | 0.078 | 0.078 | 0.078 |
| Specified/recommended Tier | 5 | 5 | 5 | 5 |
| Biomass (t) | 597,884 | 597,884 | 524,624 | 524,624 |
| $F_{OFL}$ (F=M) | 0.078 | 0.078 | 0.078 | 0.078 |
| $maxF_{ABC}$ (maximum allowable = 0.75x $F_{OFL}$) | 0.0585 | 0.0585 | 0.0585 | 0.0585 |
| $F_{ABC}$ | 0.0585 | 0.0585 | 0.0585 | 0.0585 |
| OFL (t) | **46,635** | 46,635 | **40,921** | 40,921 |
| maxABC (t) | 34,976 | 34,976 | **30,691** | 30,691 |
| ABC (t) | **34,976** | 34,976 | **30,691** | 30,691 |
| **Status** | As determined *last* year for: 2012 | 2013 | As determined *this* year for: 2013 | 2014 |
| Overfishing | No | n/a | No | n/a |

[a]The values for biomass, OFL, and ABC in these two columns are based on Rodgveller and Hulson 2013. They are an average of the last three trawl surveys that sampled down to 1,000 m. The current values (for 2015 and 2016) are from the random effects model fit to survey biomass by region and depth strata.
These are unofficial ABC and OFL values since grenadier are an Ecosystem Component, which do not have ABCs or OFLs.

## Bering Sea and Aleutian Islands Grenadiers

| Quantity | As estimated or specified *last* year for[a]: 2014 | 2015 | As estimated or recommended *this* year for: 2015 | 2016 |
|---|---|---|---|---|
| *M* (natural mortality) | 0.078 | 0.078 | 0.078 | 0.078 |
| Specified/recommended Tier | 5 | 5 | 5 | 5 |
| Biomass (t) | 1,152,284 | 1,152,284 | 1,286,734 | 1,286,734 |
| $F_{OFL}$ (F=M) | 0.078 | 0.078 | 0.078 | 0.078 |
| $maxF_{ABC}$ (maximum allowable = 0.75x $F_{OFL}$) | 0.0585 | 0.0585 | 0.0585 | 0.0585 |
| $F_{ABC}$ | 0.0585 | 0.0585 | 0.0585 | 0.0585 |
| OFL (t) | **89,878** | 89,878 | **100,365** | 100,365 |
| maxABC (t) | 67,409 | 67,409 | **75,274** | 75,274 |
| ABC (t) | **67,409** | 67,409 | **75,274** | 75,274 |
| **Status** | As determined *last* year for: 2012 | 2013 | As determined *this* year for: 2013 | 2014 |
| Overfishing | No | n/a | No | n/a |

[a]The values for biomass, OFL, and ABC in these two columns are based on Rodgveller and Hulson 2013.
These are unofficial ABC and OFL values since grenadier are an Ecosystem Component, which do not have ABCs or OFLs.

Tier 5 computations for giant grenadier OFL and ABC are summarized as follows (AI = Aleutian Islands, EBS = Eastern Bering Sea, GOA = Gulf of Alaska; biomass, OFL, and ABC are in mt) for 2015:

**BSAI and GOA grenadiers**

| Area | Biomass | Natural mortality *M* | OFL definition | OFL | ABC definition | ABC |
|---|---|---|---|---|---|---|
| EBS | 553,557 | 0.078 | biom x *M* | 43,177 | OFL x 0.75 | 32,383 |
| AI | 733,177 | 0.078 | biom x *M* | 57,188 | OFL x 0.75 | 42,891 |
| BSAI total | 1,286,734 | | | 100,365 | | 75,274 |
| GOA | 524,624 | 0.078 | biom x *M* | 40,921 | OFL x 0.75 | 30,691 |
| Grand total | 1,811,358 | | | 141,286 | | 105,965 |

These are unofficial ABC and OFL values since grenadier are an Ecosystem Component, which do not have ABCs or OFLs.

The specifications in the GOA for 2015 differ from last year because a random effects model fit to the survey biomass was used as a proxy for the exploitable biomass in this year's assessment (following the recommendation of the Survey Averaging Working group). In the BSAI the ABC and OFL include the AI biomass estimated using the method presented in the 2012 SAFE report (Rodgveller et al. 2012). Further discussion of this method is below under SSC comments and under the Survey Data section. Catches are not approaching unofficial OFLs.

## Summaries for Plan Team

| Species | Year | BSAI Biomass | BSAI ABC | BSAI Catch[1] | GOA Biomass | GOA ABC | GOA Catch[1] | Total Catch[1] |
|---|---|---|---|---|---|---|---|---|
| grenadiers | 2013 | 1,733,797 | 101,427 | 4,164 | 597,884 | 34,976 | 11,339 | 15,504 |
| | 2014 | 1,152,284 | 89,878 | 2,627 | 597,884 | 34,976 | 5,236 | 7,863 |
| | 2015 | 1,286,734 | 75,274 | | 524,624 | 30,691 | | |
| | 2016 | 1,286,734 | 75,274 | | 524,624 | 30,691 | | |

[1]Current as of October 7, 2014. Source: NMFS Alaska Regional Office Catch Accounting System via the Alaska Fisheries Information Network (AKFIN) database (http://www.akfin.org).

## SSC and Plan Team Comments on Assessments in General

There were no comments on assessments in general that pertains to this assessment.

## SSC and Plan Team Comments Specific to this Assessment

Here we report comments from the SSC in 2012 and 2013, since there was an executive summary in 2013. We also present comments from 2013 regarding the EA/RIR/IRFA on grenadier that pertain to stock assessment. Responses to these comments and additions to the document were also made in the final EA/RIR/IRFA document (NMFS 2014.)

***"The authors introduced a new method for determining AI biomass and variance estimates. The SSC cautions that this is an uncertain extrapolation method. The catchability and size selection of longline surveys is known to differ from the trawl survey. This method assumes that the ratio between longline and trawl surveys in shallow water will be the same for the ratio of longline and trawl surveys in deep water. The SSC encourages the authors to verify whether this assumption is valid."*** **(SSC, 2012)**

The primary problem with using the AI trawl survey biomass estimates for giant grenadier is that the survey does not sample deeper than 500 m; where the majority of the giant grenadier population can be found. To account for the missing biomass from the trawl survey an expansion method is needed, for which we use the AFSC longline survey data, the only survey that samples deeper than 500 m in the AI.

The primary uncertainty associated with this method centers on the use of a ratio estimator between trawl survey biomass and longline survey RPWs. The ratio between trawl survey biomass and longline survey RPWs is assumed to be the same in shallow depths (1-500 m, for which we have trawl survey data) and deep depths (500-1000 m, for which we do not have trawl survey data), an assumption that must be made due to the available data. There may be uncertainty associated with extrapolating trawl survey biomass in this manner. Our opinion is that it is important to present estimates of deep-water biomass so that a better reflection of the potential grenadier biomass in the AI can be presented.

A comparison of the ratio of longline and trawl survey data in shallow- and deep-waters in the Gulf of Alaska is presented in an attempt to verify the assumption of constant catchability in each survey in shallow- and deep-water (See "Biomass estimation in the AI" under the "Trawl Surveys" section). Ratios between the two surveys in shallow- and deep-water were almost identical in the GOA, indicating that the assumption is valid.

The trends in RPWs and biomass were compared in the EBS and the GOA to determine if the two surveys are sampling the same population. Trends in the EBS tracked well, but trends in the GOA were not consistent among the two surveys (See "RPWs" under the "Longline surveys" section), so this did not validate nor contradict the effect of the differing selectivities of the two surveys.

***"In response to SSC comments, the authors included a Kalman filter model for estimating biomass. The Kalman filter estimates miss the most recent trawl biomass estimate in the GOA resulting in a substantially lower biomass estimate. For future assessments, the SSC encourages continued exploration of the Kalman filter method and we ask the authors to consider the recommendations in the Plan Team survey averaging work group*** **(SSC, Dec. 2012)."**

The survey averaging working group has recommended that for Tier 5 stocks authors should compare biomass estimates using random effects models to the standard calculations. We compared status quo to a Kalman filter in 2012 (Rodgveller et al. 2012). Here we use the random effects model to estimate GOA biomass for 2013. Approximately ½ of the grenadier biomass was in the deepest stratum (701-1,000 m) and this stratum was not sampled in 2011 or 2013. It is likely that it will not be sampled in 2015. The random effects model provides a method to incorporate all available trawl survey data since 1984. See the section titles "Biomass Estimation in the GOA" under the "Surveys" heading for details.

***"As a non-specified species complex the Plan Teams and the SSC are not required to provide harvest specifications for this species group. Given the potential that grenadier management may change in 2014, the SSC requests a full assessment next year."*** **(SSC, Dec. 2013)**

Because grenadiers were put into the FMPs as an Ecosystem Component in 2014, there are still no harvest specifications and no requirement to produce SAFE reports. Therefore, instead of presenting a full assessment, we are presenting an abbreviated assessment that contains a time series of catch and survey data and descriptions of new methodologies used for estimating biomass.

*Comments on the EA/RIR/IRFA in 2013*

***"The SSC reviewed the document and concluded that it is very well done and ready for release for public review.*** *However, the SSC identified several areas where the document could be improved and requests that staff strive to make these improvements prior to release."* (SSC, Dec. 2013)

***"It would be useful to develop a food web for the slope regions as part of the ecosystem concerns chapter..."* (SSC, Dec. 2013)**

Little information is available on food web and habitat interactions between grenadiers and other groundfish. The information that is available indicates that in the Aleutian Islands, the diet of grenadiers is comprised mostly squid and bathypelagic fish (myctophids) (Yang 2003), whereas in the Gulf of Alaska, squid and pasiphaeid shrimp predominated as prey (Yang et al. 2006). Thus, other groundfish do not appear to compose the prey field of grenadiers.

***"The 2012 appendix revealed strong spatial partitioning of the sexes by depth. The SSC requests the author to estimate the sex ratio for survey biomass estimates in the assessment. The SSC requests that, if possible, the document should provide trawl and longline survey biomass estimates by sex and depth."* (SSC, Dec. 2013)**

In response to these comments, an appendix was added to the EA/RIR/IRFA with tables and figures that broke out catch, biomass, and RPWs by sex and depth (NMFS, 2013; see pages 77-82). We include a summary of that analysis as well as the data tables and figures presented in the EA/RIR/IRFA as an appendix to this SAFE report.

***"With respect to depth, the SSC requests that the document includes a short discussion of the potential uncertainty associated with the expansion method used to estimate grenadier biomass at deeper depths in the AI."* (SSC, Dec. 2013)**

See SSC comment from 2012 (above).

**"The SSC also encourages the author to address comments and suggestions made by the non-target CIE review team if they are relevant to the grenadier appendix." (SSC, Dec. 2013)**

See below.

## Center of Independent Expect Review Comments

In May, 2013 there was a Center of Independent Expert (CIE) review of non-target assessments at the AFSC. Three reviewers participated and each produced a report without collaboration from NMFS or other reviewers. Here I will summarize the comments pertaining to grenadier. General comments about the tier system are excluded.

**1) The three CIE reviewers did not consider the estimates of absolute biomass to be reliable for grenadier, or for other reviewed species. The catchabilities of grenadier by the bottom trawl surveys is the EBS, AI, and GOA are unknown, but are currently assumed to be 1. One reviewer recommends using expert knowledge to estimate the availability, vulnerability, and density in trawlable and untrawlable grounds to explore converting the trawl survey data to absolute biomass.**

There is some evidence, based on diets and anecdotal evidence of higher catch rates when longline gear is held off off-bottom by rocky topography, that grenadier spend time off-bottom. If this is true, $q$ is likely <1 for trawl gear. There have been no studies to estimate $q$ for grenadier.

**2) There were concerns over the ratio that is used to extrapolate the relative population numbers and weights in the western AI from a ratio of western to eastern AI data from the 1980’s.**

The western AI has not been sampled by the domestic NMFS longline survey. Data from Japanese surveys are used to extrapolate western AI abundance. This method is used for all species, including sablefish, since it is the only available data.

**3) The reviewers supported using models for estimating biomass, such as a Kalman filter or random effects model.**

This year we use a random effects model to estimate GOA biomass.

**4) A reviewer said that maximum age methods used for estimating natural mortality are acceptable, but recommended for swapping otoliths with other labs.**

The AFSC lab is the only lab that ages giant grenadier. A method was developed by Charles Hutchinson in the Age and Growth Laboratory for a previous age at maturity study (Rodgveller et al. 2010). Ages could not be validated using C14. This is likely because young fish are not in shallower waters (<200 m). Young fish are needed to confirm annuli at age 1-5; however, no young fish have been found in surveys or fisheries.

## Introduction

Grenadiers (family Macrouridae) are deep-sea fishes related to hakes and cods that occur world-wide in all oceans. Also known as “rattails”, they are especially abundant in waters of the continental slope, but some species are found at abyssal depths. At least seven species of grenadier are known to occur in Alaskan waters, but only three are commonly found at depths shallow enough to be encountered in commercial fishing operations or in fish surveys: giant grenadier (*Albatrossia pectoralis*), Pacific grenadier (*Coryphaenoides acrolepis*), and popeye grenadier (*Coryphaenoides cinereus*) (Mecklenburg et al. 2002). Of these, giant grenadier has the shallowest depth distribution and the largest apparent biomass, and hence is by far the most frequently caught grenadier in Alaska. Because of this importance, this report will emphasize giant grenadier, but it will also discuss the other two species.

*Distribution*: Giant grenadier range from Baja California, Mexico around the arc of the north Pacific Ocean to Japan, including the Bering Sea and the Sea of Okhotsk (Mecklenburg et al. 2002), and they are also found on seamounts in the Gulf of Alaska and on the Emperor Seamount chain in the North Pacific (Clausen 2008). In Alaska, they are especially abundant on the continental slope in waters >400 m depth.

These fish are the largest in size of the world's grenadier species (Iwamoto and Stein 1974); maximum weight of one individual in a Bering Sea trawl survey was 41.8 kg[1].

*Speciation*: Previous publications (Clausen 2006 and 2008) speculated that more than one species of giant grenadier may exist in Alaska because two morphs of the fish have been observed based primarily on the relative size of the eye to the head, as well as three very different patterns of otolith morphology. Tissue and otoliths samples were collected on the AFSC longline survey in 2013 for a more definitive analysis of speciation, stock structure, and otolith morphometrics.

*Biology*: There is some known biological information on adult giant grenadier, but data on larvae and juvenile grenadiers is nonexistent. The spawning period is thought to be protracted and may even extend throughout the year (Novikov 1970; Rodgveller et al. 2010). Two papers provide purported descriptions of larvae of giant grenadier in the North Pacific (Endo et al. 1993; Ambrose 1996), but Busby (2004) points out that these descriptions appear so different that they probably represent separate species. At any rate, no larvae have ever been collected in Alaska that correspond to either of these descriptions or to the description of a third form (Busby 2004) that is also giant grenadier-like[2]. Small, juvenile fish less than ~15-20 cm pre-anal fin length (PAFL) are virtually absent from bottom trawl catches (Novikov 1970; Ronholt et al. 1994; Hoff and Britt 2009, 2011), and juveniles may be pelagic in their distribution. (Because the long tapered tails of grenadiers are frequently broken off when the fish are caught, PAFL is the standard unit of length measurement for these fish. PAFL is defined to be the distance between the tip of the snout and the insertion of the first anal fin ray). Bottom trawl studies indicate that females and males have different depth distributions, with females inhabiting shallower depths than males. For example, both Novikov (1970) in Russian waters and Clausen (2008) in Alaskan waters found that nearly all fish <600 m depth were female, and the Novikov study was based on trawl sampling throughout the year. Presumably, some vertical migration of one or both sexes must occur for spawning purposes; Novikov (1970) speculates that females move to deeper water inhabited by males for spawning.

*Ecology*: The habitat and ecological relationships of giant grenadier are likewise little known and uncertain. Clearly, adults are often found in close association with the bottom, as evidenced by their large catches in bottom trawls and on longlines set on the bottom. However, based on a study of the food habits of giant grenadier off the U.S. west coast, Drazen et al. (2001) concluded that the fish feeds primarily in the water column. Most of the prey items found in the stomachs were meso- or bathypelagic squids and fish, and there was little evidence of benthic feeding. Smaller studies of giant grenadier food habits in the Aleutian Islands (Yang 2003) and Gulf of Alaska (Yang et al. 2006) showed similar results. In the Aleutian Islands, the diet comprised mostly squid and bathypelagic fish (myctophids), whereas in the Gulf of Alaska, squid and pasiphaeid shrimp predominated as prey. The hypothesis regarding the tendency of the fish to feed off bottom is supported by observations of sablefish longline fishermen, who report that their highest catches of giant grenadier often occur when the line has been inadvertently "clothes-lined" between two pinnacles, rather than set directly on the bottom[3]. Pacific sleeper sharks (*Somniosus pacificus)* and Baird's beaked whales (*Berardius bairdii*) have been documented as predators on giant grenadier (Orlov and Moiseev 1999; Walker et al. 2002). Sperm whales (*Physeter macrocephalus*) are another likely predator, as they are known to dive to depths inhabited by giant

[1] G. Hoff, National Marine Fisheries Service, Alaska Fisheries Science Center, RACE Division, 7600 Sand Point Way NE, Seattle WA 98115. Pers. comm. March 2005.
[2] M. Busby, National Marine Fisheries Service, Alaska Fisheries Science Center, RACE Division, 7600 Sand Point Way NE, Seattle WA 98115. Pers. comm. October 2006.
[3] D. Clausen, National Marine Fisheries Service, Alaska Fisheries Science, Auke Bay Laboratories, 17109 Point Lena Loop Rd., Juneau, AK 99801. Pers. observ. October 2004.

grenadier on the continental slope and have been observed in Alaska depredating on longline catches of giant grenadier[4].

*Distribution of Pacific and popeye grenadier*: Pacific grenadier have a geographic range nearly identical to that of giant grenadier, i.e., Baja California, Mexico to Japan. Popeye grenadier range from Oregon to Japan. Compared to giant grenadier, both species are much smaller and generally found in deeper water. They appear to be most abundant in waters >1,000 m, which is deeper than virtually all commercial fishing operations and fish surveys in Alaska. For example, in a recent experimental longline haul in the western Gulf of Alaska at a depth of 1400-1500 m, 56% of the hooks caught Pacific grenadier[5]. This indicates that at least in some locations in deep water, abundance of Pacific grenadier in Alaska can be extremely high. Few popeye grenadier are caught on longline gear, apparently because of the relatively small size of these fish, and most of the information on this species comes from trawling. Food studies off the U.S. West Coast indicate that Pacific grenadier are more benthic in their habitat than are giant grenadier, as the former species fed mostly on bottom organisms such as polychaetes, mysids, and crabs (Drazen et al. 2001).

*Evidence of stock structure:* Stock structure and migration patterns of giant grenadier in Alaska are unknown, as no genetics studies have been done (except for brief genetic investigation of the two morphs of this species that was previously mentioned), and the fish cannot be tagged because all individuals die due to barotrauma when brought to the surface. One study in Russian waters, however, used indirect evidence to conclude that seasonal feeding and spawning migrations occur of up "to several hundred miles" (Tuponogov 1997).

*Natural mortality*: In the 2014 assessment we continue to use the natural mortality estimate ($M$) of 0.078, calculated using Hoenig's (1983) longevity equation with a maximum age of 58 from a study of age at maturity for giant grenadier (Rodgveller et al. 2010). A discussion of the four methods employed by Rodgveller et al. (2010) and the reason for choosing Hoenig's (1983) method can be found in the 2010 grenadier SAFE (Clausen and Rodgveller 2010). Giant grenadier greater than 60 cm PAFL have been caught on the AFSC longline survey, whereas the greatest length in the age samples was 53 cm (Rodgveller et al. 2010). Therefore, it is probable that fish older than 58 exist. An older maximum age would result in a decrease in $M$. Because fish older than 58 years may exist, we suggest revisiting the determination of $M$ for giant grenadier if more age samples become available in the future.

## Fishery

*Catch History*

Catches since 1997 have been estimated for the eastern Bering Sea (EBS), Aleutian Islands (AI), and GOA based largely on data from the Alaska Fishery Science Center's Fishery Monitoring and Analysis program. The estimates for 1997-2002 were determined by simulating the catch estimation algorithm used for target species by the NMFS Alaska Regional Office in what was formerly called their "blend catch estimation system" (Gaichas 2002 and 2003). Although these estimates may not be as accurate as the official catch estimates determined for managed groundfish species, they are believed to be the best possible based on the data available. They do not appear unreasonable compared to the official catches of other species caught along with giant grenadier on the continental slope in Alaska, such as sablefish and

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[4] C. Lunsford, National Marine Fisheries Service, Alaska Fisheries Science Center, Auke Bay Laboratories, 17109 Point Lena Loop Rd., Juneau, AK 99801. Pers. comm. October 2006.
[5] D. M. Clausen and C. J. Rodgveller, 2010. Deep-water longline experimental survey for giant grenadier and sablefish in the western Gulf of Alaska, August 2008. National Marine Fisheries Service, Alaska Fisheries Science Center, Auke Bay Laboratories, 17109 Point Lena Loop Rd., Juneau, AK 99801. Unpubl. manuscr. 23p.

Greenland turbot. The estimates for 2003-2014 were computed by the NMFS Alaska Regional Office based on their Catch Accounting System, which replaced the “blend” system in 2003. All the data are presented as “grenadiers, all species combined”.

In 2013 the observer program underwent restructuring. Implementation of this program is considered an improvement over the previous observer system and an analysis of the first year under the restructured program was presented at the June 2014 council meeting (Faunce et al. 2014). It is too early to determine if there are any changes in the time series due to this restructuring. More years of data are needed. There is now observer coverage of vessels <60 ft and of the IFQ Pacific halibut fleet. A description of changes in bycatch rate calculations and changes that occurred in CAS that relate to non-target species can be found in Tribuzio et al. (2014).

Overall, the estimate of total catch of grenadier in 2013 (15,504 mt) was almost the same as in 2012 (15,119 mt) (Table 1). Catch in 2013 was up 13% from the 2003-2012 average. Even though the great majority of grenadier catch occurs by Oct. 1, the catch estimate in 2014 is only 7,863 mt. For example, by Oct. of 2013 95% of the catch was taken. Thus we expect that the final catch estimate for 2014 will be much lower than average. It is possible that this is related to observer restructuring.

In the BSAI catch was down 21% (1,092 mt) from average in 2013 (Table 1). This was primarily in the Greenland turbot fishery in the BS and the Kamchatka flounder fishery in the AI (Table 2). In the GOA, grenadier catch was higher in 2013 than in previous years (2,890 mt above average; 34%; Table 1). The majority of this increase was in rockfish (461 mt; 84% above average), sablefish (1,476 mt; 22% above average) (Table 2), and the deep-water flatfish fisheries (1,063 mt; 581% above average) (Table 2). Surprisingly, the estimate of grenadier catch in the halibut target group was 47% below average in 2013; although, catch estimates in this target group have always been variable.

## Survey Data

*Trawl Surveys*

*Biomass estimation in GOA*: The Plan Team Survey Averaging Plan Team working group and the SSC suggested that for tier 5 species authors should compare biomass estimates using a random effects model to standard calculations. For grenadier a Kalman filter model was presented in 2012 (Rodgveller et al. 2012). This year we used a random effects model to estimate exploitable biomass for unofficial ABCs and OFLs (Table 3). The only GOA trawl surveys that extended to 1,000 m include the surveys in 1984, 1987, 1999, 2005, 2007, and 2009. In 1990, 1993, 1996, and 2001 the trawl survey only sampled depths down to 500 m, and in 2003 and 2011 the trawl survey sampled depths up to 700 m. Due to the differences in the depth sampled among the various trawl surveys, and the distribution of giant grenadier biomass across depth strata, we applied the random effects model to biomass estimates for the 1-500 m, 501-700 m, and 701-1000 m depth strata by region separately. This resulted in three time series of biomass estimates: one for each depth stratum. The full time series of biomass estimates in the GOA from the random effects model were then obtained by summing the biomass estimates across the three depth strata (Figure 1). Biomass in the GOA, estimated using the random effects model, increased until 2005 and then decreased slowly and then increased in 2013 (Figure 1). Compared to status quo, biomass estimates from the random effects model are lower (Table 3) (ratios of random effects biomass/status quo biomass range from 0.76 to 0.97).

*Biomass estimation in AI*: The Aleutian Islands have presented a special problem for biomass estimation because no trawl surveys since 1986 have sampled waters deeper than 500 m, where most giant grenadier biomass is found. In previous SAFEs (Clausen 2006; Clausen and Rodgveller 2008, Clausen and

Rodgveller 2010) an AI biomass was estimated by using a combination of data from other areas and surveys: the GOA and EBS slope trawl surveys and the AFSC longline survey (Clausen and Rodgveller, 2010).

In 2012, a new method was used to estimate giant grenadier biomass that utilizes only AI survey data (Rodgveller et al. 2012; Appendix 1A and in the "survey data" section), and we continue to use this method. The AI trawl survey biomass estimates from the "shallow" depths, which are regularly sampled (1-500 m), and AI longline survey RPWs from "shallow" (200-500 m) and "deep" depths (501-1000 m) are used to estimate the total AI biomass using the following equation:

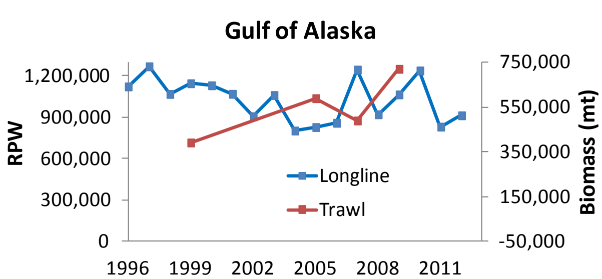
$$(1)\ B_y = \bar{r} W_y$$

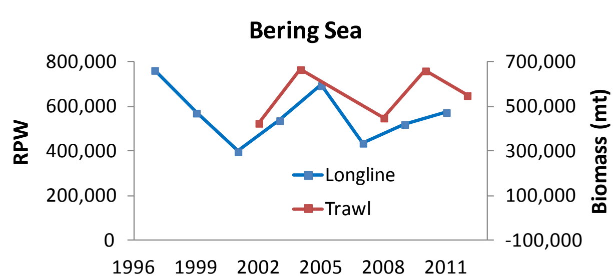
where $B_y$ is the total biomass in year $y$, $\bar{r}$ is the ratio of the sum of bottom trawl survey biomass estimates to the sum of longline RPWs in the shallow depth stratum for years when both surveys occurred (2000, 2002, 2004, 2006, 2010, 2012, 2014), and $W_y$ is the total RPW in year $y$. $\bar{r}$ of "shallow" biomass to "shallow" RPWs for these years was 0.223. For those years when the AFSC longline survey occurs in the AI, an AI biomass estimate is now available (Table 4). Estimated biomass increased in 2014 by 53%. It is now similar to the estimated biomass in 2010.

When using this method, there is an assumption that the ratio between longline and trawl surveys in shallow water is the same as the ratio of longline and trawl surveys in deep water. In an attempt to validate this assumption, we examined the ratios of the two surveys in shallow- and deep-water in the GOA, where the trawl survey sampled down to 700 m in 2003 and 2011 and to 1,000 m in 1999, 2005, 2007, and 2009. In the GOA, the shallow ratio was nearly the same as the deep ratio (using the same method employed for calculating the AI shallow ratio), indicating that the assumption that the shallow- and deep-water ratios in the AI are similar is likely valid.

| max depth | years | shallow ratio | deep ratio |
|---|---|---|---|
| 700 m | 2003,2011 | 0.60 | 0.62 |
| 1,000 m | 1999,2005,2007,2009 | 0.52 | 0.51 |
| all years | | 0.60 | 0.52 |

There is some evidence that trawl and longline survey abundance trends are similar. This may indicate that these surveys are sampling the same population and lend credence to the method we use to extrapolate AI biomass from longline survey data. Trawl and longline survey abundance trends can be compared in the GOA and EBS, since some trawl surveys sampled to at least 1,000 m in these areas. Longline and trawl surveys did not occur in the same years in the EBS (trawl survey was in even years and longline was in odd). The trends in the two surveys in the EBS tracked well. The trends in the GOA were not similar; however, there were not many trawl surveys in the GOA that sampled down to 1,000m within a short time frame (4 surveys over 10 years) vs. 5 years in the EBS.



*Biomass in the EBS:* There was no slope trawl survey in 2014. Biomass point estimates have ranged from 426-660 thousand mt between 2002 and 2012 (Table 4). Biomass was almost identical to the average in 2012 (550,266 mt), which was 17% lower than the estimate in 2010.

*Longline Surveys*

*RPWs*: RPWs of giant grenadier in the GOA had a general decreasing trend from 1999 through 2004, increased through 2007, and have been somewhat decreasing since then (Table 5). In 2014 the RPW in the GOA was 19% below average, which is well within the range of values in other years. RPWs in the Bering Sea have been increasing since 2007. In 2013 the biomass was 7% above average. The biomass of giant grenadier in the AI is larger than in other areas. This is because there is a large population estimated to be in the western Aleutians. This area is not currently sampled, but a ratio of eastern to western areas from previous surveys is used to extrapolate RPWs to these areas. In 2014, the AI RPW was 26% above average.

## Analytic Approach

*Modeling Approach*

The tier 5 computations have been based only on giant grenadier because virtually none of the other species are caught in the commercial fishery or surveys. The exploitable biomass in the GOA was previously based on averaging the biomass estimates in the last three trawl surveys that extended to 1,000 m. The deepest stratum (701-1,000 m) was not sampled in 2011 or 2013, therefore, since 2009 the same estimate of biomass has been used for ABC/OFL calculations. This year we use a random effects model, presented in the 2012 SAFE report (Rodgveller et al. 2012), which utilizes trawl survey data from 1984-2013 to estimate the exploitable biomass in 2013 (see section above under Survey data, trawl surveys). Since there was no trawl survey in the GOA in 2014, the estimate for 2013 is used as the most recent value of exploitable biomass. To estimate exploitable biomass in the BS and AI, we continue to use an average of the three most recent trawl surveys with data available down to 1,000 m. For the BS that is 2008, 2010, and 2012. For the AI that is 2010, 2012, 2014. In the future we may use a random effects model in the Bering Sea to estimate biomass.

*Parameter Estimates*

*Maximum Age*: The most recent aging studies for giant grenadiers (Burton 1999 and Rodgveller et al. 2010) found the maximum age to be 56 and 58 years, respectively, based on specimens from the GOA. There have been no aging studies for Pacific grenadier in Alaska, but Andrews et al. (1999) found a maximum age of 73 years for this species off the U.S. west coast.

*Natural mortality*: In the 2014 assessment we continue to use the natural mortality estimate (*M*) of 0.078, calculated using Hoenig’s (1983) longevity equation with a maximum age of 58 from a study of age at maturity for giant grenadier (Rodgveller et al. 2010).

## Results

*Harvest Recommendations*

*Parameters used*: In the previous stock assessment for grenadiers (Rodgveller et al. 2013), the NPFMC's tier 5 approach for determining the OFL and ABC was recommended, and this approach was supported by both the GOA Groundfish Plan Team and the NPFMC's Scientific and Statistical Committee. We again use tier 5 unofficial ABC and OFL calculations.

*Methods:* Current biomass estimates in this assessment for giant grenadier in the EBS and GOA were calculated based on the average of the three most recent deep-water trawl surveys that sampled down to 1,000 or 1,200 m. In the EBS, these are now the 2008, 2010, and 2012 surveys. In the AI a method used in the 2012 SAFE was used to calculate biomass down to 1,000 m, even when trawl surveys sampled only to 500 m. Details are in Rodgveller et al. (2012). Estimates of AI biomass used for calculations of ABC and OFL are now based on 2010, 2012, and 2014.

The current GOA biomass was estimated using a random effects model (see section above under "Trawl Surveys"); therefore a single estimate is used as an estimate of exploitable biomass. This method is preferable to averaging the last three trawl surveys that sampled down to 1,000 m because trawl surveys have not extended this deep since 2009. The deepest stratum (700-1,000 m) will not likely be sampled in the near future.

The NPFMC's tier 5 definitions for OFL and ABC are: OFL = *M* x *Biomass*, where *M* is the estimated natural mortality rate, and ABC is $\leq$(0.75 x OFL). Based on our discussion above, tier 5 recommendations for OFL and ABC of grenadiers are listed below (biomass, OFL, ABC, and mean catch are in mt).

**BSAI and GOA grenadiers**

| Area | Biomass | Natural mortality *M* | OFL definition | OFL | ABC definition | ABC |
|---|---|---|---|---|---|---|
| EBS | 553,557 | 0.078 | biom x *M* | 43,177 | OFL x 0.75 | 32,383 |
| AI | 733,177 | 0.078 | biom x *M* | 57,188 | OFL x 0.75 | 42,891 |
| BSAI total | 1,286,734 | | | 100,365 | | 75,274 |
| GOA | 524,624 | 0.078 | biom x *M* | 40,921 | OFL x 0.75 | 30,691 |
| Grand total | 1,811,358 | | | 141,286 | | 105,965 |

**Gulf of Alaska Grenadiers**

| Quantity | As estimated or specified *last* year for[a]: 2014 | 2015 | As estimated or recommended *this* year for: 2015 | 2016 |
|---|---|---|---|---|
| *M* (natural mortality) | 0.078 | 0.078 | 0.078 | 0.078 |
| Specified/recommended Tier | 5 | 5 | 5 | 5 |
| Biomass (t) | 597,884 | 597,884 | 524,624 | 524,624 |
| $F_{OFL}$ (F=M) | 0.078 | 0.078 | 0.078 | 0.078 |
| $maxF_{ABC}$ (maximum allowable = 0.75$x$ $F_{OFL}$) | 0.0585 | 0.0585 | 0.0585 | 0.0585 |
| $F_{ABC}$ | 0.0585 | 0.0585 | 0.0585 | 0.0585 |
| OFL (t) | **46,635** | 46,635 | **40,921** | 40,921 |
| maxABC (t) | 34,976 | 34,976 | **30,691** | 30,691 |
| ABC (t) | **34,976** | 34,976 | **30,691** | 30,691 |
| **Status** | As determined *last* year for: 2012 | 2013 | As determined *this* year for: 2013 | 2014 |
| Overfishing | No | n/a | No | n/a |

[a]The values for biomass, OFL, and ABC in these two columns are based on Rodgveller and Hulson 2013. They are an average of the last three trawl surveys that sampled down to 1,000 m. The current values (for 2015 and 2016) are from the random effects model fit to survey biomass by region and depth strata.

**Bering Sea and Aleutian Islands Grenadiers**

| Quantity | As estimated or specified *last* year for[a]: 2014 | 2015 | As estimated or recommended *this* year for: 2015 | 2016 |
|---|---|---|---|---|
| *M* (natural mortality) | 0.078 | 0.078 | 0.078 | 0.078 |
| Specified/recommended Tier | 5 | 5 | 5 | 5 |
| Biomass (t) | 1,152,284 | 1,152,284 | 1,286,734 | 1,286,734 |
| $F_{OFL}$ (F=M) | 0.078 | 0.078 | 0.078 | 0.078 |
| $maxF_{ABC}$ (maximum allowable = 0.75$x$ $F_{OFL}$) | 0.0585 | 0.0585 | 0.0585 | 0.0585 |
| $F_{ABC}$ | 0.0585 | 0.0585 | 0.0585 | 0.0585 |
| OFL (t) | **89,878** | 89,878 | **100,365** | 100,365 |
| maxABC (t) | 67,409 | 67,409 | **75,274** | 75,274 |
| ABC (t) | **67,409** | 67,409 | **75,274** | 75,274 |
| **Status** | As determined *last* year for: 2012 | 2013 | As determined *this* year for: 2013 | 2014 |
| Overfishing | No | n/a | No | n/a |

[a]The values for biomass, OFL, and ABC in these two columns are based on Rodgveller and Hulson 2013.

*Not subject to over fishing*: The recommended OFLs and ABCs in the above tables are much larger than the mean catches for grenadiers and also much larger than the catch in any single year, which indicates catches could increase without endangering the stocks. This is especially true for the EBS and AI, where the exploitation rate appears to be quite low.

## Ecosystem Considerations

A determination of ecosystem considerations for grenadiers in Alaska is hampered by the extreme lack of biological and habitat information for these species and by limited knowledge in general on the deep slope environment inhabited by these fish.

*Ecosystem Effects on the Stocks*

*Prey availability/abundance trends*: The only food studies on grenadiers in the northeast Pacific have been on adults. One study of giant grenadier off the U.S. west coast concluded that the fish fed primarily off-bottom on bathy- and mesopelagic food items that included gonatid squids, viperfish, deep-sea smelts, and myctophids (Drazen et al. 2001). Smaller studies of giant grenadier food habits in Alaska showed generally similar results. In the Aleutian Islands, the diet comprised mostly squid and myctophids (Yang 2003), whereas in the Gulf of Alaska, squid and pasiphaeid shrimp predominated as prey (Yang et al. 2006). Research on these deep-sea prey organisms in Alaska has been virtually non-existent, so information on prey availability or possible variations in abundance of prey are unknown. Very few juvenile giant grenadier have ever been caught, so nothing is known about their food preferences.

In contrast to giant grenadier, a study of Pacific grenadier food habits off the U.S. west coast found a much higher consumption of benthic food items such as polychaetes, cumaceans, mysids, and juvenile Tanner crabs (*Chionoecetes* sp.), especially in smaller individuals (Drazen et al. 2001). Carrion also contributed to its diet, and larger individuals consumed some pelagic prey including squids, fish, and bathypelagic mysids.

*Predator population trends*: The only documented predators of giant grenadier are Pacific sleeper sharks (Orlov and Moiseev 1999) and Baird's beaked whales (Walker et al. 2002). According to Orlov's and Moiseev's study, giant grenadier was ranked third in relative importance as a food item in the diet of these sharks. Sperm whales are another potential predator, as they are known to dive to depths inhabited by giant grenadier on the slope and have been observed depredating on longline catches of giant grenadier[6]. Giant grenadier is a relatively large animal that is considered an apex predator in its environment on the deep slope (Drazen et al. 2001), so it may have relatively few predators as an adult. Predation on larval and juvenile giant grenadiers would likely have a much greater influence on the ultimate size of the adult population size, but information on predators of these earlier life stages is nil.

*Changes in habitat quality*: Little or no environmental information has been collected in Alaska for the deep slope habitat in which grenadiers live. This habitat is likely more stable oceanographically than shallower waters of the upper slope or continental shelf. Regime shifts on the continental shelf and slope in Alaska in recent decades have been well documented, but it is unknown if these shifts also extend to the deep slope. Regime shifts could have a pronounced effect on giant grenadier if their larvae or post-larvae inhabited upper portions of the water column. However, no larvae or post-larvae for this species have ever been collected in Alaska. The absence of larvae or post-larvae giant grenadier in larval surveys in Alaska, which have nearly all been conducted in upper parts of the water column, implies that larval giant grenadier may reside in deeper water, where they may be less affected by regime shifts since water temperatures in deep water tend to be more stable.

*Fishery Effects on the Ecosystem*

[6] C. Lunsford, National Marine Fisheries Service, Alaska Fisheries Science Center, Auke Bay Laboratories, 17109 Point Lena Loop Rd., Juneau, AK 99801. Pers. comm. Oct 2012.

Because there has been virtually no directed fishing for grenadiers in Alaska, the reader is referred to the discussion on Fishery Effects in the sablefish SAFE report. The sablefish longline fishery is the main fishery that takes giant grenadier as bycatch, so the Fishery Effects section in the sablefish report is applicable to giant grenadier and is an indication of what the effects might be if a directed fishery for giant grenadier were to develop. It should be noted that because all grenadiers presently caught in the sablefish and Greenland turbot fisheries are discarded and do not survive, this constitutes a major input of dead organic material to the ecosystem that would not otherwise be there.

## Data Gaps and Research Priorities

*Research priorities*

1) Because early life history information for giant grenadier is nil, studies are also needed to investigate where larvae and young juveniles reside.
2) Evaluation of the catchability of giant grenadier in the bottom trawl surveys, which would affect the accuracy of subsequent biomass estimates. Studies are needed on whether this fish is a completely benthic species or if individuals sometimes move off-bottom.
3) Validation of the AFSC REFM Division aging methodology for giant grenadier.
4) Further analysis and study of competition for hooks that may affect giant grenadier catch rates on the AFSC longline survey.
5) Continue a study to examine if the three different shapes of otoliths found in giant grenadier represent separate species or subpopulations. This is an ongoing cooperative project between the Marine Ecology and Stock Assessment program at Auke Bay Laboratories (ABL), REFM Age and Growth Lab, and the ABL genetics lab.

*Current Research*

Three otolith shapes were previously identified by Charles Hutchinson, AFSC Age and Growth Lab, in giant grenadier. A review of the literature revealed that this level of variability in otolith shape is extremely unusual for an individual fish species. These three otolith types may indicate that genetic subspecies or subpopulations exist for giant grenadier in Alaska that are not apparent based on the external morphology of the fish. Tagging studies are a traditional way to determine migration patterns and spatial stock structure for fish. However, these studies are not possible for giant grenadier because the fish do not survive the pressure difference when caught at depth and brought to the surface. Genetic and otolith microchemistry studies are an alternative means for determining patterns of stock structure.

In 2013, otolith and tissue samples were collected from giant grenadier in the eastern, central and western GOA and the EBS. Otoliths will be aged and photographed for morphometric measurements in 2015. Tissues are currently being analyzed by Scott Vulstek and Charles Guthrie, AFSC Auke Bay Laboratories genetics program. After genetic and morphometric data is collected, we will compare results from the two studies.

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Table 1.—Updated catch data (mt) for grenadiers, nearly all of which are thought to be giant grenadier, as of October 7, 2014 (NMFS Alaska Regional Office Catch Accounting System via the Alaska Fisheries Information Network (AKFIN) database, http://www.akfin.org). The estimates for 2003-2012 were computed by the NMFS Alaska Regional Office based on their Catch Accounting System, which replaced the "blend" system in 2003. Observer restructuring began in 2013 so the mean from 2003-2012 is presented for comparison to 2013 and 2014.

| | Eastern Bering Sea | Aleutian Islands | Gulf of Alaska | Total |
|---|---|---|---|---|
| 1997 | 2,964 | 2,887 | 12,029 | 17,881 |
| 1998 | 5,011 | 1,578 | 14,683 | 21,272 |
| 1999 | 4,505 | 2,883 | 11,388 | 18,776 |
| 2000 | 4,067 | 3,254 | 11,610 | 18,931 |
| 2001 | 2,294 | 1,460 | 9,685 | 13,439 |
| 2002 | 1,891 | 2,807 | 10,479 | 15,177 |
| 2003 | 2,641 | 3,036 | 10,843 | 16,520 |
| 2004 | 2,225 | 1,251 | 10,471 | 13,946 |
| 2005 | 2,633 | 1,795 | 6,606 | 11,034 |
| 2006 | 2,068 | 2,225 | 8,515 | 12,808 |
| 2007 | 1,645 | 1,817 | 9,629 | 13,091 |
| 2008 | 1,687 | 1,800 | 11,167 | 14,654 |
| 2009 | 2,983 | 3,681 | 6,696 | 13,360 |
| 2010 | 2,928 | 3,690 | 5,564 | 12,181 |
| 2011 | 4,333 | 2,578 | 7,437 | 14,349 |
| 2012 | 2,926 | 4,625 | 7,568 | 15,119 |
| 2013 | 1,629 | 2,535 | 11,339 | 15,504 |
| 2014 | 876 | 1,751 | 5,236 | 7,863 |
| Mean 2003-2012 | 2,607 | 2,650 | 8,450 | 13,706 |

Table 2.—Estimated catch (mt) of grenadiers (all species combined) in the eastern Bering Sea, Aleutian Islands, and Gulf of Alaska, by target species/species group, 2003-2011. Arrow = arrowtooth flounder; DW flat = deep-water flatfish; GT = Greenland turbot; halibut = Pacific halibut; Kam = Kamchatka flounder; cod = Pacific cod; rex = rex sole; sable = sablefish; other sp. = other species combined (including yellowfin sole, rock sole, shallow-water flatfish, "other flatfish", flathead sole, and all other species). Source: Regional Office Catch Accounting System accessed through the Alaska Fisheries Information Network (AKFIN), October 7, 2014.

| | Target species/species group | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Year | arrow | DW flat | GT | halibut | Kam | cod | rex | rockfish | sable | other |
| | | | | | Aleutian Islands | | | | | |
| 2003 | | | 113 | 1,376 | | 46 | | 6 | 1,494 | 0 |
| 2004 | | | 14 | 414 | | 13 | | 60 | 748 | 1 |
| 2005 | | | 161 | 617 | | 2 | | 21 | 979 | 16 |
| 2006 | 341 | | 328 | 172 | | 121 | | 154 | 1,109 | 0 |
| 2007 | 108 | | 342 | 69 | | 41 | | 21 | 1,161 | 76 |
| 2008 | 397 | | 67 | 229 | | 26 | | 59 | 746 | 276 |
| 2009 | 1,377 | | 414 | | | 12 | | 152 | 1,642 | 84 |
| 2010 | 1,674 | | 210 | 44 | | 259 | | 168 | 1,127 | 206 |
| 2011 | 51 | | 83 | 13 | 723 | 18 | | 292 | 1,292 | 105 |
| 2012 | 264 | | | 113 | 2,56 | 55 | | 38 | 1,167 | 428 |
| 2013 | 278 | | 44 | 239 | 406 | 3 | | 215 | 1,139 | 212 |
| 2014 | 254 | | | 63 | 295 | 23 | | 218 | 842 | 56 |
| | | | | | Eastern Bering Sea | | | | | |
| 2003 | 38 | | 1,452 | 355 | | 240 | | 9 | 370 | 164 |
| 2004 | 24 | | 1,315 | 254 | | 240 | | 22 | 287 | 83 |
| 2005 | 11 | | 1,977 | 143 | | 333 | | 32 | 108 | 31 |
| 2006 | 125 | | 1,192 | 174 | | 130 | | 12 | 420 | 16 |
| 2007 | 2 | | 1,073 | 89 | | 179 | | 17 | 215 | 70 |
| 2008 | 69 | | 708 | 392 | | 163 | | 3 | 127 | 226 |
| 2009 | 243 | | 1,823 | | | 212 | | 6 | 692 | 8 |
| 2010 | 186 | | 2,036 | 36 | | 390 | | 126 | 145 | 8 |
| 2011 | 807 | | 1,799 | 7 | 241 | 1,13 | | 17 | 316 | 5 |
| 2012 | 673 | | 1,464 | 61 | 5 | 514 | | 3 | 179 | 27 |
| 2013 | 272 | | 533 | 321 | 12 | 274 | | 47 | 166 | 4 |
| 2014 | 120 | | 377 | 143 | 10 | 100 | | 2 | 113 | 10 |

Table 2.—continued.

| | Target species/species group | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Year | Arrow | DW flat | GT | Halibut | Kam Fl | Cod | Rex | Rockfish | Sable | Other |
| | | | | Gulf of Alaska | | | | | | |
| 2003 | 27 | 474 | | 710 | | 5 | 325 | 613 | 8,464 | 223 |
| 2004 | 171 | 178 | | 156 | | 0 | 5 | 2,231 | 7,657 | 74 |
| 2005 | 103 | | | 488 | | | 4 | 212 | 5,743 | 56 |
| 2006 | 18 | | | 766 | | 22 | 4 | 338 | 7,243 | 124 |
| 2007 | 90 | 20 | | 530 | | 79 | 5 | 198 | 8,702 | 5 |
| 2008 | 3 | | | 1,918 | | 97 | 89 | 164 | 8,651 | 244 |
| 2009 | | | | 1,430 | | 79 | 102 | 227 | 4,816 | 43 |
| 2010 | 40 | 60 | | 243 | | 149 | 140 | 511 | 4,359 | 62 |
| 2011 | 114 | | | 172 | 723 | 69 | 229 | 529 | 6,208 | 116 |
| 2012 | 155 | | | 18 | 2,561 | 173 | 2 | 438 | 6,666 | 116 |
| 2013 | 161 | 1,246 | | 338 | 406 | 169 | 4 | 1,008 | 8,327 | 87 |
| 2014 | 387 | | | 259 | 295 | 162 | 5 | 602 | 3,803 | 19 |

Table 3.—Biomass estimates for grenadier in the Gulf of Alaska using a random effects model. Estimates are for 1-1,000 m in all years. Left: estimates from using a random effects model. Center: estimates from NMFS trawl surveys that sampled down to 1,000 m. Right (status quo): biomass estimates used in SAFE reports for specifications of unofficial ABCs and OFLs since 2006. Biomass in 2006 was calculated as the average of the last two trawls surveys that sampled down to 1,000 m. Years after that the last three trawl surveys were averaged.

| | Random Effects | | | Surveys down to 1,000 m | | | |
|---|---|---|---|---|---|---|---|
| Year | Biomass | U 95% CI | L 95% CI | Biomass | U 95% CI | L 95% CI | Status quo |
| 1984 | 175,388 | 227,242 | 135,366 | 169,708 | 228,015 | 111,401 | |
| 1985 | 170,807 | 225,204 | 129,548 | | | | |
| 1986 | 166,557 | 218,599 | 126,905 | | | | |
| 1987 | 162,617 | 208,284 | 126,963 | 135,971 | 188,211 | 83,731 | |
| 1988 | 167,761 | 226,612 | 124,193 | | | | |
| 1989 | 173,766 | 244,626 | 123,432 | | | | |
| 1990 | 180,602 | 262,528 | 124,242 | | | | |
| 1991 | 193,747 | 286,163 | 131,177 | | | | |
| 1992 | 209,763 | 311,007 | 141,477 | | | | |
| 1993 | 229,936 | 337,265 | 156,763 | | | | |
| 1994 | 243,428 | 356,531 | 166,204 | | | | |
| 1995 | 257,863 | 371,900 | 178,794 | | | | |
| 1996 | 273,315 | 381,925 | 195,591 | | | | |
| 1997 | 299,036 | 404,975 | 220,811 | | | | |
| 1998 | 331,011 | 428,314 | 255,814 | | | | |
| 1999 | 371,879 | 443,349 | 311,930 | 389,908 | 466,030 | 313,786 | |
| 2000 | 397,273 | 505,803 | 312,029 | | | | |
| 2001 | 427,155 | 544,558 | 335,063 | | | | |
| 2002 | 453,259 | 588,879 | 348,873 | | | | |
| 2003 | 482,870 | 598,383 | 389,656 | | | | |
| 2004 | 493,499 | 626,562 | 388,695 | | | | |
| 2005 | 507,214 | 609,381 | 422,176 | 587,346 | 754,202 | 420,489 | |
| 2006 | 477,897 | 596,180 | 383,081 | | | | 488,627 |
| 2007 | 463,065 | 568,252 | 377,349 | 487,987 | 629,173 | 346,802 | 488,414 |
| 2008 | 452,765 | 624,873 | 328,061 | | | | 488,414 |
| 2009 | 455,461 | 749,608 | 276,738 | 718,320 | 1,484,296 | 0 | 597,884 |
| 2010 | 460,223 | 818,702 | 258,709 | | | | 597,884 |
| 2011 | 473,685 | 898,965 | 249,595 | | | | 597,884 |
| 2012 | 496,996 | 996,834 | 247,789 | | | | 597,884 |
| 2013 | 524,624 | 1,099,917 | 250,229 | | | | 597,884 |
| 2014 | 524,624 | 1,194,419 | 230,431 | | | | 597,884 |

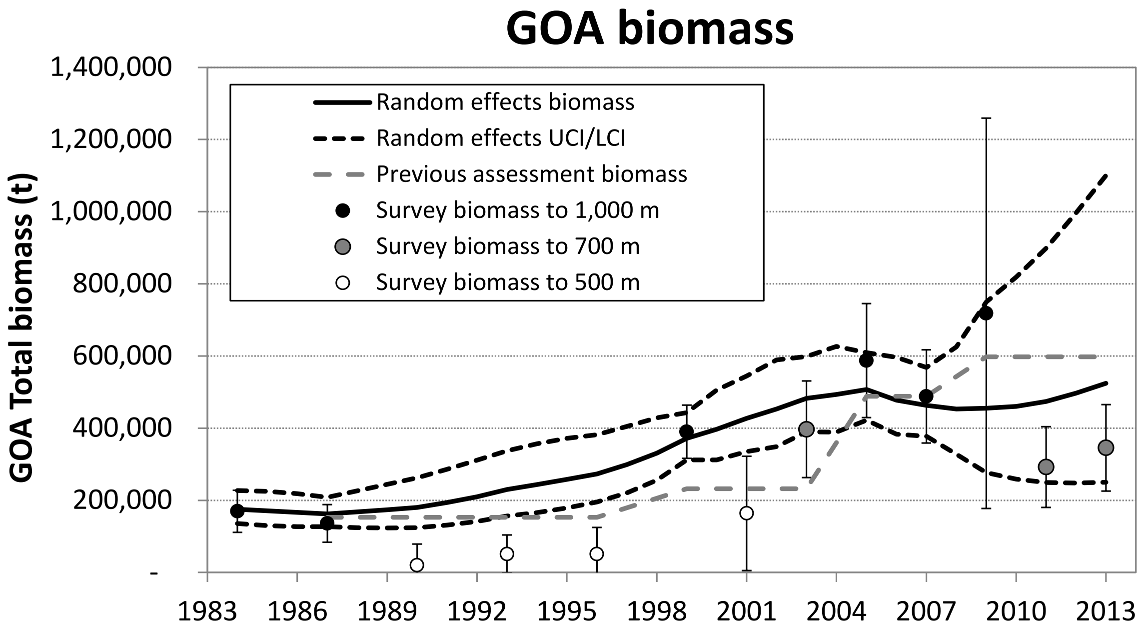
Table 4.—Biomass estimates (mt) and associated 95% confidence bounds (mt), variances, and coefficients of variation (cv) for giant grenadier in recent NMFS surveys in Alaska that sampled the upper continental slope. The Gulf of Alaska surveys included depths to 1,000 m, whereas the eastern Bering Sea slope surveys included depths to 1,200 m. Aleutian Islands biomass was estimated from trawl survey biomass estimates from 1-500 m and AFSC longline survey relative population weights from 200-1000m (see section titled "survey data").

| | | | 95% Conf. bounds | | | |
|---|---|---|---|---|---|---|
| Region | Year | Biomass | Lower | Upper | Variance | cv (%) |
| Aleutian Islands | 2000 | 560,200 | 290,106 | 830,294 | 18,989,690,223 | 24.6 |
| Aleutian Islands | 2002 | 570,239 | 295,651 | 844,828 | 19,626,898,754 | 24.6 |
| Aleutian Islands | 2004 | 575,396 | 297,497 | 853,295 | 20,103,051,745 | 24.6 |
| Aleutian Islands | 2006 | 721,531 | 373,113 | 1,069,950 | 31,600,203,801 | 24.6 |
| Aleutian Islands | 2008 | 365,940 | 189,744 | 542,136 | 8,081,265,243 | 24.6 |
| Aleutian Islands | 2010 | 688,251 | 356,757 | 1,019,745 | 28,604,825,470 | 24.6 |
| Aleutian Islands | 2012 | 478,991 | 246,867 | 711,115 | 14,025,825,748 | 24.7 |
| Aleutian Islands | 2014 | 733,177 | 379,987 | 1,086,366 | 32,471,605,527 | 24.6 |
| Eastern Bering Sea | 2002 | 426,397 | 344,922 | 507,871 | 1,659,519,194 | 9.6 |
| Eastern Bering Sea | 2004 | 666,508 | 527,524 | 805,491 | 4,829,084,657 | 10.4 |
| Eastern Bering Sea | 2008 | 449,777 | 353,902 | 545,652 | 2,298,003,647 | 10.7 |
| Eastern Bering Sea | 2010 | 660,528 | 521,035 | 800,021 | 4,864,588,623 | 10.6 |
| Eastern Bering Sea | 2012 | 550,366 | 433,097 | 667,635 | 3,437,997,235 | 10.6 |

Table 5.—Giant grenadier relative population weight, by region, in AFSC longline surveys in Alaska, 1990-2014. Dashes indicate years that the eastern Bering Sea or Aleutian Islands were not sampled by the survey. Gulf of Alaska values include data only for the upper continental slope at depths 201-1,000 m and do not include continental shelf gullies sampled in the surveys. Note: relative population weight, although an index of biomass (weight), is a unit-less value. NA indicates that length data is not available for calculations of RPWs. AFSC longline survey database query, October 2014.

| Year | Eastern Bering Sea | Aleutian Islands | Gulf of Alaska |
|---|---|---|---|
| 1992 | - | - | 686,827 |
| 1993 | - | - | 1,041,508 |
| 1994 | - | - | 1,018,292 |
| 1995 | - | - | 1,264,245 |
| 1996 | - | 2,281,815 | 1,121,058 |
| 1997 | 762,639 | - | 1,266,800 |
| 1998 | - | 2,268,918 | 1,066,477 |
| 1999 | 571,852 | - | 1,277,141 |
| 2000 | - | 3,039,523 | 1,143,980 |
| 2001 | 398,950 | - | 1,067,335 |
| 2002 | - | 3,093,994 | 904,922 |
| 2003 | 538,190 | - | 1,058,570 |
| 2004 | - | 3,121,973 | 801,271 |
| 2005 | 694,456 | - | 826,495 |
| 2006 | - | 3,914,871 | 857,510 |
| 2007 | 437,268 | - | 1,242,833 |
| 2008 | - | 1,985,511 | 919,083 |
| 2009 | 521,179 | - | 1,063,104 |
| 2010 | - | 3,734,301 | 1,236,692 |
| 2011 | 574,349 | - | 829,476 |
| 2012 | - | 3,230,202 | 911,728 |
| 2013 | 605,727 | - | 896,776 |
| 2014 | - | 3,978,057 | 848,321 |
| mean | 567,179 | 3,151,928 | 1,012,140 |

Figure 1.—Biomass estimates of giant grenadier from NMFS bottom trawl surveys and from a random effects model that utilizes trawl survey biomass estimates from all years (with 95% confidence intervals). The estimates of exploitable biomass used in previous assessments are also presented. From 1987-1996 this was the average of the last two trawl surveys that extended down to 1,000 m. From 1999-2013, it was the average of the biomass from the most recent three surveys that sampled down to 1,000 m.



Appendix A. Giant grenadier depth distribution by sex in fisheries and surveys.

Method and Results

*Catch*

Observed grenadier catch, not estimated total catch, was split by sex using sex ratios from observer specimen data, i.e., fish that had their lengths taken from 2003-2013 (Table 1; Figure 1). This timeframe was chosen because catch estimates are available for grenadier since 2003. Length frequencies by sex, stratum, and FMP area were converted to weights using area (BS, AI, and GOA) and sex specific growth curves from AFSC trawl surveys. The percent males by weight were used to split the observed catch for the Bering Sea (BS), Aleutian Islands (AI), and the Gulf of Alaska (GOA) by stratum (Table 2). The same percentages were used for splitting BS and AI observed catch (Table 1).
Total estimated grenadier catch from the Catch Accounting System (CAS) was split by sex using sex ratios of weight from observer specimen data (Table 3), as described above, except a single proportion was used for all depth strata combined because catch is not available by depth from CAS. The percent male was 13% in the BSAI and 15% in the GOA.

*AFSC Longline Survey*

The AFSC longline survey stations are spaced systematically (~20-30 km apart) along the slope from the eastern Gulf of Alaska west to the Aleutian Islands and north into the eastern Bering Sea. At each station, depths from ~150-1000 m are sampled. Giant grenadier are caught in great numbers throughout the survey range, primarily in depths from 400-1,000 m. The Aleutian Islands are sampled in even years, the Bering Sea in odd years, and the Gulf of Alaska is sampled annually. Because the area that is sampled by the longline cannot be defined, an index of abundance in weight is calculated, called relative populating weight (RPW), but is not a measure of absolute biomass. The index is used for tracking trends in abundance.

Giant grenadier length frequencies are available since 2006. Length frequencies by sex, stratum, and area (AI, BS, GOA) were converted to weights using area and sex specific growth curves from AFSC trawl surveys. The percent males, by weight, for each depth strata and area were calculated (Table 4) and used to split the RPWs by sex and stratum (Table 5, Figure 2).

*AFSC Gulf of Alaska Trawl Survey*

The AFSC GOA trawl survey samples the continental shelf and slope where stations are randomly chosen within depth strata. Only surveys that sampled down to 1,000 m were included in this analysis (1999, 2005, 2007, and 2009); surveys in 1984 and 1987 were not included because survey methodology changed in 1996. In other years, surveys sampled down to only 500 or 700 m and are not reflective of the extent of grenadier distribution by sex.

Giant grenadier population length frequencies are available split by sex for each depth stratum. We converted these population length frequencies to weight (biomass) using sex specific growth curves from GOA trawl survey data (Table 6). The biomass split by sex, year, and strata, as well as the percent of giant grenadier biomass that is male, is presented in Table 6. For comparison to the longline survey and observed catch, the average biomass by sex and strata are shown in Figure 3. Bering Sea trawl survey biomass estimates spilt by sex are not currently available and will be examined in the future.

Discussion

The observed catch is primarily between depths of 201-400 m; however, this is not where the bulk of giant grenadier biomass is found (e.g., see figures 1 and 2 for AFSC longine and trawl survey data). Observer length data shows that the percent of the catch that is male, by weight, increases with depth in the GOA, but there is the opposite trend in the BSAI. Although, the decreasing trend in male abundance is not dramatic in the BSAI and sample sizes for several depths strata are small. Due to small sampled sizes, the apparent trend in the BSAI may not be representative of the true distribution of giant grenadier. There is a much greater proportion of male grenadier in the catch data compared to the longline survey. This could be partially explained by the diverse gear types in the fisheries that incidentally catch grenadier; however, a large proportion of the observed grenadier catch is from longline fisheries. The difference between the proportion of males in longline survey and fishery could also be attributed to seasonal variation in depth distribution. The longline survey takes place only in the summer, whereas fisheries take place nearly year round. More time is required to explore distribution differences in the fishery by season and we plan to examine this in the future.

The trawl survey had a greater proportion of males than the longline survey and the proportion of males increased with depth in all surveys. The sex proportions in the trawl survey were more similar to the fishery than the longline survey when all depths are considered; however, in the 1-500 depth stratum the trawl survey had a very low percentage of males (2-5%), whereas the majority of the fishery data was from 201-400 m and the percentage male was larger than 5% (12-16%).

In all data sources, including surveys and fisheries, the large majority of catch is females. Also, overall the proportion of male grenadier, by weight, increases with deeper depths. Taken together, this information indicates that our surveys and fisheries may not completely cover the range of grenadier distribution. However, it also indicates that a disproportionate harvest of females is occurring, and should continue to be monitored.

Although a portion of the male population may reside in depths deeper than surveys and fisheries, it is possible that there is not a 1:1 ratio of males to females. We have not aged males and, therefore, it is not known if the natural mortality rate is different between sexes for grenadiers. Given the sexual dimorphism in growth and differences in distribution by sex, it could be postulated that other life-history parameters, like natural mortality, may also vary by sex. For example, in some flatfish species there is sexual dimorphism in natural mortality, where males have a much higher rate than females (e.g., arrowtooth flounder, 0.2 for females and 0.35 for males). If this is true for grenadier, the sex ratio may not be 1:1. The number of females could be larger than the number of males. Even in a deep-water AFSC longline survey (down to 1,600 m in the WGOA), on average 24% were male by number. Also, because females were much larger at depths >1,000 m than depths <1,000 m, the weight ratio would likely be much less than 24%.

Table 1. Sum of observed giant grenadier catch in mt for males (M) and females (F) from 2003-2013.

| | Aleutian Islands | | | Bering Sea | | | Gulf of Alaska | | |
|---|---|---|---|---|---|---|---|---|---|
| Depth strata | AI | AI F | AI M | BS | BS F | BS M | GOA | GOA F | GOA M |
| 1-100 | 31 | 27 | 5 | 441 | 383 | 58 | 69 | 59 | 10 |
| 101-200 | 802 | 701 | 106 | 1,280 | 1,113 | 166 | 1,891 | 1,607 | 284 |
| 201-300 | 10,183 | 8,855 | 1,328 | 5,300 | 4,610 | 692 | 8,849 | 7,522 | 1,327 |
| 301-400 | 6,338 | 5,512 | 828 | 8,457 | 7,355 | 1,104 | 8,726 | 7,415 | 1,309 |
| 401-500 | 265 | 230 | 34 | 788 | 684 | 104 | 671 | 570 | 101 |
| 501-600 | 4 | 4 | 0 | 8 | 6 | 0 | 20 | 16 | 1 |
| 601-700 | 0 | 0 | 0 | 2 | 2 | 0 | 4 | 4 | 0 |
| 701-800 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 3 | 0 |
| 801-900 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 |

Table 2. Percent of male giant grenadier in observed catch from 2003-2013 in numbers and weight. Weights were calculated from length frequencies by depth, sex, and area using sex specific growth curves from the AFSC trawl survey. The total sample size (n) for length frequencies is presented for each sex.

| | BSAI | | GOA | |
|---|---|---|---|---|
| Depth (m) | % male (numbers, weight) | n | % male (numbers, weight) | n |
| 1-100 | | 0 | 17%, 15% | 6 |
| 101-200 | 25%, 22% | 296 | 9%, 7% | 690 |
| 201-300 | 19%, 16% | 4,535 | 14%, 12% | 6,623 |
| 301-400 | 17%, 14% | 8,013 | 20%, 16% | 11,986 |
| 401-500 | 23%, 17% | 719 | 28%, 21% | 1,603 |
| 501-600 | 20%, 13% | 155 | 37%, 24% | 123 |
| 601-700 | 11%, 6% | 22 | 56%, 54% | 18 |
| 701-800 | | 0 | 20%, 12% | 5 |

Table 3. Total estimated grenadier catch from 2003-2013 split by sex (mt). Observed lengths were converted to weights using area and sex specific growth curves and the percent male was calculated using these weights. The average proportion of males and females by weight in the catch was used to split catch.

| Year | BS total | BS male | BS female | AI total | AI Male | AI Female | GOA total | GOA male | GOA female |
|---|---|---|---|---|---|---|---|---|---|
| 2003 | 2,869 | 373 | 2,439 | 3,558 | 463 | 3,024 | 12,253 | 1,838 | 10,415 |
| 2004 | 2,223 | 289 | 1,890 | 1,251 | 163 | 1,063 | 11,989 | 1,798 | 10,191 |
| 2005 | 2,633 | 342 | 2,238 | 1,795 | 233 | 1,526 | 7,251 | 1,088 | 6,163 |
| 2006 | 2,067 | 269 | 1,757 | 2,195 | 285 | 1,866 | 8,429 | 1,264 | 7,165 |
| 2007 | 1,631 | 212 | 1,386 | 1,544 | 201 | 1,312 | 9,119 | 1,368 | 7,751 |
| 2008 | 2,820 | 367 | 2,397 | 2,525 | 328 | 2,146 | 11,333 | 1,700 | 9,633 |
| 2009 | 2,902 | 377 | 2,467 | 3,739 | 486 | 3,178 | 6,326 | 949 | 5,377 |
| 2010 | 2,799 | 364 | 2,379 | 3,553 | 462 | 3,020 | 5,419 | 813 | 4,606 |
| 2011 | 4,221 | 549 | 3,588 | 2,596 | 337 | 2,207 | 8,216 | 1,232 | 6,984 |
| 2012 | 2,276 | 296 | 1,935 | 4,383 | 570 | 3,726 | 7,206 | 1,081 | 6,125 |
| 2013 | 1,482 | 193 | 1,260 | 2,367 | 308 | 2,012 | 10,525 | 1,579 | 8,946 |
| average | 2,538 | 330 | 2,158 | 2,682 | 349 | 2,280 | 8,915 | 1,337 | 7,578 |

Table 4. Percent of fish that were male caught during the AFSC longline survey 2006-2013 in numbers and weight. Weights were calculated from length frequencies by depth, sex, and area using sex specific growth curves from the AFSC trawl survey. The total sample size (n) for length frequencies is presented for each sex.

| | Aleutian Islands | | Bering Sea | | Gulf of Alaska | |
|---|---|---|---|---|---|---|
| Depth (m) | % male (numbers, weight) | n | % male (numbers, weight) | n | % male (numbers, weight) | n |
| 101-200 | 0%, 0% | 20 | 0%, 0% | 9 | 0%, 0% | 11 |
| 201-300 | 0%, 0% | 312 | 0%, 0% | 582 | 0.5%, 0.8% | 2,098 |
| 301-400 | 0%, 0% | 1,280 | 0%, 0% | 1,559 | 1%, 0.5% | 9,947 |
| 401-600 | 2%, 2% | 2,912 | 0%, 0% | 2,949 | 2%, 1% | 19,527 |
| 601-800 | 6%, 5% | 2,533 | 2%, 1% | 3,038 | 5%, 3% | 17,378 |
| 801-1000 | 20%, 15% | 777 | 6%, 4% | 1,015 | 9%, 6% | 8,603 |
| Total | 5%, 4% | 7,834 | 2%, 1% | 9,255 | 4%, 3% | 58,828 |

Table 5. Average AFCS longline survey Relative Population Weights split by sex and strata from 2006-2013.

| | Aleutian Islands | | Bering Sea | | Gulf of Alaska | |
|---|---|---|---|---|---|---|
| Strata (m) | AI M | AI F | BS M | BS F | GOA M | GOA F |
| 201-300 | 0 | 16,322 | 7 | 9,263 | 152 | 17,772 |
| 301-400 | 189 | 93,257 | 0 | 39,385 | 477 | 95,590 |
| 401-600 | 6,707 | 299,368 | 285 | 121,839 | 3,613 | 279,659 |
| 601-800 | 17,890 | 348,645 | 2,854 | 232,902 | 10,020 | 283,846 |
| 801-1000 | 37,164 | 218,898 | 6,692 | 148,634 | 17,131 | 271,927 |

Table 6. AFCS Gulf of Alaska trawl survey biomass estimates from recent years when the survey sampled down to 1,000 m (1999, 2005, 2007, 2009).

| Depth strata (m) | Year | GOA M | GOA F | % male |
|---|---|---|---|---|
| 1-500 | 1999 | 2,183 | 126,234 | 2% |
| 1-500 | 2005 | 10,698 | 226,337 | 5% |
| 1-500 | 2007 | 3,163 | 103,382 | 3% |
| 1-500 | 2009 | 1,510 | 89,961 | 2% |
| 501-700 | 1999 | 15,336 | 136,471 | 10% |
| 501-700 | 2005 | 25,470 | 221,437 | 10% |
| 501-700 | 2007 | 16,467 | 218,538 | 7% |
| 501-700 | 2009 | 29,116 | 142,184 | 17% |
| 701-1000 | 1999 | 28,466 | 81,219 | 26% |
| 701-1000 | 2005 | 28,522 | 74,882 | 28% |
| 701-1000 | 2007 | 46,574 | 99,862 | 32% |
| 701-1000 | 2009 | 83,034 | 372,514 | 18% |

Figure 1. Summed observed grenadier catch from 2003-2013, not total estimated catch, split by sex and depth strata.

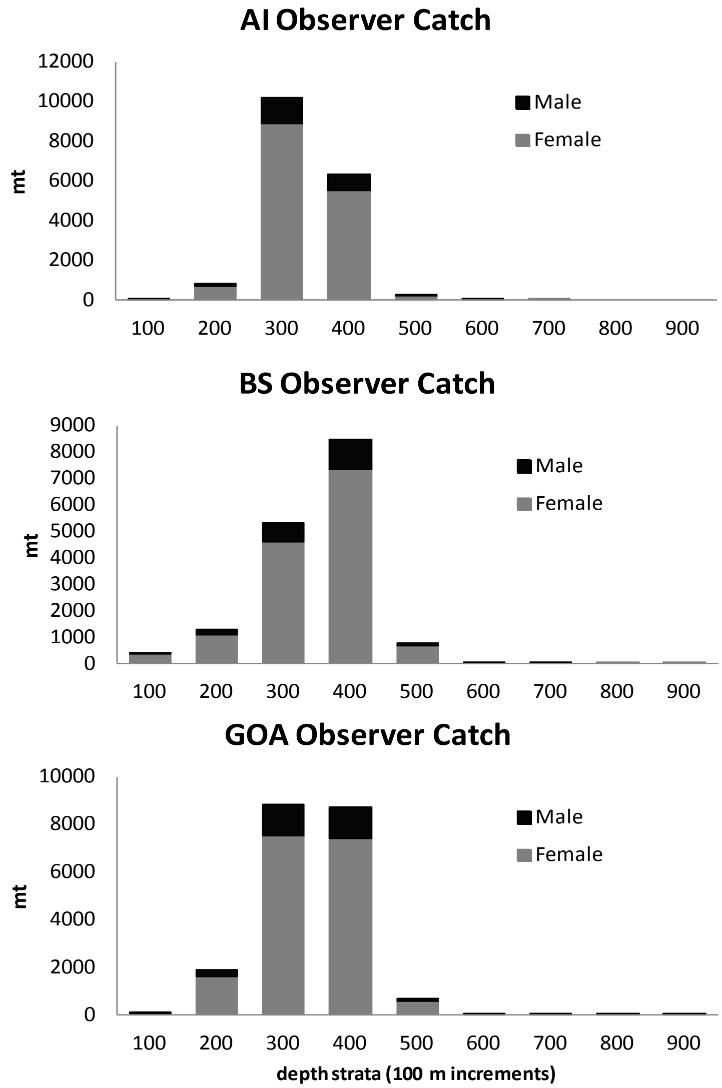


Figure 2. Average AFCS longline survey giant grenadier Relative Population Weights from 2006-2013 split by sex and depth stratum.

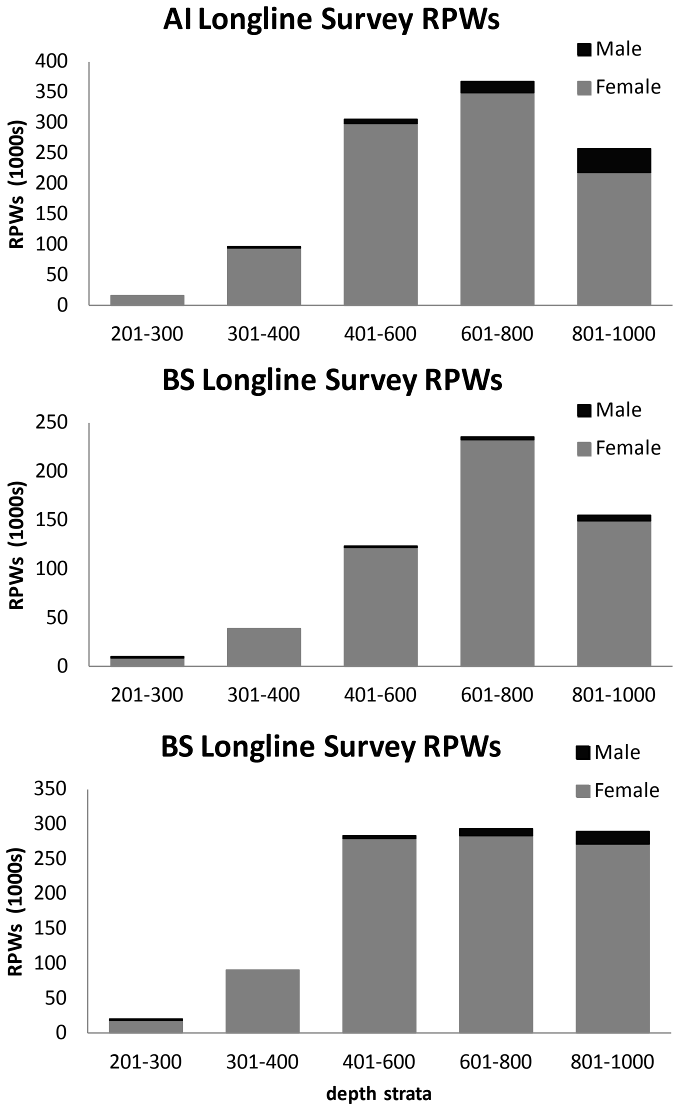
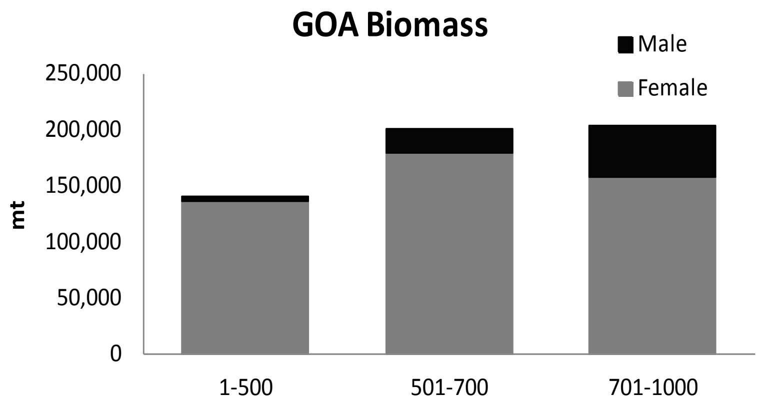


Figure 3. Average GOA AFCS trawl survey giant grenadier biomass estimates in 1999, 2005, 2007, and 2009 split by sex and strata (recent years when the survey sampled down to 1,000 m).



Appendix B

Tabbe 1B-1.—Research catch (mt) of grenadier (giant, popeye, and pacific grenadier, but primarily giant grenadier) in AFSC trawl and longline (LL) surveys and the International Pacific Halibut Commission (IPHC) longline survey. Only numbers are available from the IPHC survey through 2009; 2010 and 2011 catch in weight is available. 0s indicate that there was catch but it is <1 mt.

| | BSAI | | | | | GOA | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | IPHC #s | IPHC wt | AFSC Trawl | AFSC LL | Total BSAI | IPHC #s | IPH C wt | AFSC Trawl | AFSC LL | Total GOA | Total |
| 1979 | | | 33 | | 33 | | | 0 | | 0 | 33 |
| 1980 | | | 85 | | 85 | | | 1 | | 1 | 86 |
| 1981 | | | 66 | | 66 | | | 3 | | 3 | 69 |
| 1982 | | | 124 | | 124 | | | 0 | | 0 | 125 |
| 1983 | | | 136 | | 136 | | | 0 | | 0 | 136 |
| 1984 | | | | | | | | 59 | | 59 | 59 |
| 1985 | | | 165 | | 165 | | | 9 | | 9 | 174 |
| 1986 | | | 90 | | 90 | | | 0 | | 0 | 90 |
| 1987 | | | 0 | | 0 | | | 42 | | 42 | 42 |
| 1988 | | | 30 | | 30 | | | | | | 30 |
| 1989 | | | | | | | | | | | |
| 1990 | | | | | | | | 3 | 128 | 131 | 131 |
| 1991 | | | 10 | | 10 | | | | 113 | 113 | 123 |
| 1992 | | | | | | | | | 117 | 117 | 117 |
| 1993 | | | | | | | | 6 | 135 | 141 | 141 |
| 1994 | | | 6 | | 6 | | | | 134 | 134 | 140 |
| 1995 | | | | | | | | | 191 | 191 | 191 |
| 1996 | | | | 38 | 38 | | | 8 | 173 | 181 | 219 |
| 1997 | 1,184 | | 9 | 78 | 87 | 258 | | | 169 | 169 | 256 |
| 1998 | 556 | | | 59 | 59 | 681 | | 12 | 141 | 153 | 212 |
| 1999 | 165 | | 0 | 57 | 57 | 660 | | 47 | 157 | 204 | 261 |
| 2000 | 774 | | 118 | 88 | 206 | 621 | | | 160 | 160 | 366 |
| 2001 | 1,313 | | | 43 | 43 | 287 | | 11 | 161 | 173 | 215 |
| 2002 | 987 | | 23 | 81 | 104 | 942 | | | 129 | 129 | 233 |
| 2003 | 1,792 | | 91 | 50 | 141 | 1,344 | | 27 | 151 | 178 | 320 |
| 2004 | 2,111 | | 196 | 78 | 274 | 1,110 | | | 109 | 109 | 383 |
| 2005 | 1,404 | | | 71 | 71 | 1,266 | | 49 | 120 | 169 | 240 |
| 2006 | 941 | | 20 | 76 | 96 | 919 | | | 112 | 112 | 208 |
| 2007 | 1,224 | | | 77 | 77 | 849 | | 44 | 166 | 209 | 286 |
| 2008 | 1,331 | | 123 | 47 | 170 | 755 | | | 120 | 120 | 290 |
| 2009 | 2,710 | | | 86 | 86 | 785 | | 39 | 154 | 193 | 279 |
| 2010 | 2,451 | 9 | 156 | 66 | 231 | 1,265 | 6 | | 164 | 170 | 401 |
| 2011 | 1,808 | 7 | | 75 | 82 | 751 | 2 | 20 | 124 | 145 | 227 |
| 2012 | | 5 | 135 | 43 | 177 | | 2 | | 132 | 132 | 310 |
| *2013 | | 5 | | 83 | 88 | | 2 | | 132 | 134 | 222 |
| *2014 | | | | 73 | 73 | | | | 127 | 127 | 200 |

*GOA trawl survey data is not available through the AKRO for grenadier for 2013 (accessed through AKFIN, October 2014). Only AFSC longline survey data is available for 2014.

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