Assessment of the Grenadier stock complex in the Gulf of Alaska, Eastern Bering Sea, and Aleutian Islands

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Executive Summary

Grenadiers are managed as a non-target species in the Gulf of Alaska (GOA), Eastern Bering Sea (EBS), and Aleutian Islands (AI) and are bycatch in directed fishing for other species. In 2015, a final rule was issued adding the grenadier stock complex as an Ecosystem Component to the GOA and BSAI Fishery Management Plans (FMPs) under Amendments 100/91. Prior to this rule they were not in the FMPs (i.e., "nonspecified"). Under this rule, grenadiers are not allowed to be targeted, but there is an 8% Maximum Retainable Allowance (MRA) (Federal Register, Proposed Rules, Vol. 79, No. 93).

Conservation, management, and a stock assessment are not required for grenadier because they are an Ecosystem Component in the GOA and BSAI FMP. No ABCs or OFLs are adopted in the annual groundfish harvest specifications. However, this abbreviated SAFE report for the BSAI and GOA is presented for tracking trends in abundance and catch. The grenadier assessment is on a 4-year cycle, and the last grenadier SAFE report was completed in 2020.

New data in this report include: 1) updated catch through 7 October 2024, 2) survey biomass estimates from the 2021 and 2023 GOA trawl survey, 3) survey biomass estimates from the 2022 and 2024 AI trawl survey, 4) survey index estimates from the 2021–2023 GOA longline survey, 5) survey index estimates from the 2022 AI longline survey, and 6) survey index estimates from the 2021 and 2023 EBS longline survey.

Summary of Results

Reliable information related to total biomass of grenadiers is not available because the shallower end of their distribution is at the deeper end of fishery-independent surveys and commercial fisheries in Alaska. This assessment is based on these limited data and does not likely capture the true dynamics of this deep-dwelling complex, but it does provide insight into grenadiers that overlap with fisheries in Alaska. Since the last grenadier complex assessment in 2020, there have been downward trends in the EBS, AI, and GOA indices. Despite the lack of biomass estimates over their entire habitat range, the ratio of catch over conservative estimates of grenadier biomass remains low.

Introduction

Grenadiers (family Macrouridae) are deep-sea fishes related to hakes and cods that occur worldwide 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 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 *C. cinereus*. Of these, giant grenadier has the shallowest depth distribution and hence is by far the most frequently caught grenadier species in Alaska. As such, this report will emphasize giant grenadier.

General 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 GOA and on the Emperor Seamount chain in the North Pacific (Clausen 2008). In Alaska, giant grenadiers are especially abundant on the continental slope in waters > 400-m depth. This species is frequently encountered between 300 and 1,800 m in the northwestern Pacific Ocean, and the densest giant grenadier catches in Russia occur in temperatures ranging from 2.8 to 3.7°C (Tuponogov et al. 2008). Females and males have different depth distributions, with females inhabiting shallower depths than males. For example, nearly all fish < 600-m depth were female in Russian waters (Novikov 1970) and Alaskan waters (Clausen 2008). Giant grenadier appear to spawn throughout the year, with peak spawning activity in the late spring season and early fall in the Bering Sea (Alferof and Kurnosov 2024). Although the majority of surveys only sample down to 1,000 m, giant grenadier were caught in a deep-water (1,000–1,500 m) experimental survey in the western GOA (Clausen and Rodgveller 2013).

Pacific grenadier have a geographic range nearly identical to that of giant grenadier, i.e., Baja California, Mexico to Japan, and 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 GOA at a depth of 1400–1500 m, 56% of the hooks caught Pacific grenadier (Clausen and Rodgveller 2013). 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.

Life History Information

Very little is known about the life history of grenadiers. The spawning period is thought to be protracted and may even extend throughout the year (Novikov 1970; Rodgveller et al. 2010); however, no larvae have been collected in Alaska. 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, the distance between the tip of the snout and the insertion of the first anal fin ray, is the standard unit of length measurement for these fish. Giant grenadier are long-lived and late to mature, with an age at 50% maturity of 23 years old. Giant grenadier are the largest of the world's grenadier species (Iwamoto and Stein 1974); maximum weight of one individual in an AFSC EBS trawl survey was 41.8 kg.

Prey and Predators

There is little known about the habitat and ecological relationships of giant grenadier. Adult giant grenadier 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. On the U.S. West Coast, giant grenadier primarily fed in the water column on meso- or bathypelagic squids and fish with little evidence of benthic feeding in their stomach contents, while Pacific grenadier were feeding primarily on bottom organisms such as polychaetes, mysids, and crabs (Drazen et al. 2001). In the Aleutian Islands, giant grenadier diet was

comprised mostly of squid and bathypelagic myctophids (Yang 2003), and in the GOA the predominant prey items included squid and pasiphaeid shrimp (Yang et al. 2006). The hypothesis regarding the tendency of the fish to feed off bottom is also 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. 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 grenadier on the continental slope and have been observed in Alaska depredating on longline catches of giant grenadier.

Stock Structure

Though multiple morphs of giant grenadier have been observed in Alaska with differing otolith morphology, they are all thought to be one species (Rodgveller et al. 2017). The reasons for the extreme variation in shape may be related to differences in habitat, but there is no information on grenadier distribution in Alaska prior to when they settle to a demersal life at approximately age 14. Because all grenadier die when brought to the surface due to barotrauma, movement cannot be elucidated through tagging studies.

Fishery and Management History

Fishery

History

Catches since 1997 have been estimated for the EBS, AI, and GOA based largely on data from the Alaska Fisheries Science Center (AFSC) Fishery Monitoring and Analysis Division. 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 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. The estimates for 2003 and later were computed by the NMFS Alaska Regional Office based on their Catch Accounting System, which replaced the "blend" system in 2003.

Starting in 2015 the grenadier complex was added to both the GOA and BSAI FMPs as an Ecosystem Component. With this change 1) retention is now recorded and 2) total catch is estimated using a combination of observer estimates of retention and from discards and retention records at landing. Retention mostly occurs in bottom trawl fisheries, where it is not possible to sort fish at-sea. Most of the retained grenadier is turned into fish meal, and a small amount of retained grenadier is used for bait. Most grenadiers are caught in deep-water bottom trawl and longline fisheries.

Catches of grenadier are at all-time lows in both the BSAI and GOA, and thus, low total catch across Alaska (Table 1, Figure 1). In the EBS, grenadier catch peaked in 2011, with a relatively high catch in the Greenland turbot *Reinhardtius hippoglossoides* and Pacific cod *Gadus macrocephalus* fisheries (Table 2), but this dropped in the following years and has remained low since 2014. In the AI, grenadier catch peaked in 2012, with a relatively high catch in the Kamchatka flounder *Atheresthes evermanni* and sablefish *Anoplopoma fimbria* fisheries (Table 3), but also dropped in the following years and has remained low since 2015. The GOA has historically dominated the grenadier catch with a peak in 2013, primarily in the sablefish fishery (Table 4). The sablefish fishery began a transition from hook and line to pots starting in 2017, and this has likely contributed to the significant decline in grenadier catch in the

GOA, though grenadier catch appears to have declined in most GOA fisheries (Figure 1, Table 4). Most grenadier catch is discarded (Tables 2–4).

Data

Survey Data

Trawl Surveys

Biomass estimates of giant grenadier are derived from the AFSC GOA trawl survey, AI trawl survey, and EBS slope trawl survey. This assessment uses GOA trawl survey data starting in 1990, and separates strata by western, central, and eastern GOA (WGOA, CGOA, and EGOA respectively) as well as 0–500 m, 501–700 m, and 701–1000 m to account for missing depths and areas (Table 5, Figure 2). The EBS slope trawl data includes deeper habitat where grenadier are found, but it is limited to 2002, 2004, 2008, 2010, 2012, and 2016 (Table 6, Figure 3). For the AI trawl survey, the maximum depth is 500 m, so it is limited for use with grenadier, and the assessment uses the triennial data from 1991 to 2000 and biennial data from 2002 to present (Table 7, Figure 4). Annual mean giant grenadier length by region shows differences by region (AI are larger than EBS and GOA) and a consistent decline in all regions through time (Figure 5). Research catch is shown in Appendix A (Table A-1).

Longline Surveys

Relative population number (RPN) estimates are a population index derived from the AFSC longline survey which annually samples the GOA and alternates between the EBS (odd years) and AI (even years). Data beginning in 1992, which primarily samples depths between 200 and 1,000 m were used, and the 2024 survey plans were cancelled (Figure 6). Relative population weight (RPW) estimates utilize length information to convert RPNs to an index of biomass. The GOA data is separated into WGOA, CGOA, and EGOA for comparison with the GOA trawl survey (Table 8). The AI data only included the eastern AI, as the effort has focused on sampling east of the 180° date line in decades (Figure 4, Table 9). Annual mean giant grenadier PAFL by region showed differences by region (BSAI are larger than GOA) and a consistent decline in all regions through time (Figure 5). These differences and changes can cause the RPWs to change differently than the RPNs. Sablefish catch per unit effort (CPUE) has been found to be negatively correlated with giant grenadier CPUE (Rodgveller et al. 2008), but no corrections were made for these indices. Research catch is shown in Appendix A (Table A-1).

Analytic Approach

Modeling Approach

A random effects multi-survey model (REMA) was used to combine trawl and longline survey data from the GOA and EBS. In the GOA, REMA was used to estimate exploitable biomass from trawl survey and longline survey data. This model estimated a common process error, a common scaling coefficient, and additional observation error for the longline survey (Sullivan et al. 2022). In the EBS, REMA was used to estimate exploitable biomass from slope trawl survey and longline survey data. This model estimated a common process error and a common scaling coefficient (Sullivan et al. 2022). In the AI region we historically combined the trawl and longline survey (Rodgveller and Siwicke 2020). This involved several extrapolations based on poorly met assumptions; consequently, we presented the AI indices on their own without using any smoothers.

Results

Note that biomass estimates for this complex must be considered conservative because our fisheries surveys only sample part of the range of depths at which grenadiers occur. In addition, our estimates were based only on giant grenadier. As such, actual biomass of the grenadier complex is likely much higher than these estimates. Index and model results were used to track trends in the areas where we had data. Downward trends in the biomass of giant grenadier were seen in all regions and surveys and appears to have been a combination of fewer giant grenadier as evidenced by declining RPNs (Figure 6) as well as smaller individuals on average in recent years (Figure 5).

In the GOA, survey data indicate that the biomass of giant grenadier was relatively low since 2020, and the REMA model indicates a decline that began in 2015 (Figures 2 & 7). The biomass appears similar in the WGOA and the CGOA, but the EGOA is much lower with a less pronounced decline. The biomass predicted for 2025 (191,650 t) is the lowest in the time series (Table 10). Even so, the catch levels in recent years (~ 1,000 t) were quite small relative to this biomass and do not cause any concern.

Giant grenadier biomass estimates from the EBS slope trawl survey were relatively low (approximately 450 kt) in 2002 and 2008 but relatively high (approximately 680 kt) in 2004 and 2010. Though the longline survey did not sample these same years, large swings occurring between 1997 and 2010 were tracked by both surveys (Figure 3). The combination of these two surveys allows new data to inform trends, and the recent declines appear to have begun around 2017 (Figure 3), but was not previously informing model estimates (Rodgveller and Siwicke 2020). The biomass predicted for 2025 (224,816 t) is the lowest in the time series (Table 11), though the catch levels in recent years (~ 1,000 t) are quite small relative to this biomass and do not cause any concern.

Indices in the AI are challenging to combine as the trawl surveys only cover relatively shallow depths (< 500 m) and fail to adequately sample grenadier, and the longline survey has limited spatial coverage. Still, both indices showed declining trends in recent years (Figure 4), consistent with trends seen in other areas. Overall, there is a large amount of grenadier habitat that is not sampled at all, such as deeper than 500 m in the western AI. The 2024 AI trawl survey found a small uptick in giant grenadier relative to 2022, though still low relative to the time series (Figure 4). Note that the longline survey finds high RPNs in the eastern AI (Figure 6) and that RPWs in the eastern AI are historically above the EBS (Table 9) suggesting giant grenadier are relatively abundant in the AI. Even with the limited information on grenadier in the AI (Tables 7 & 9), catch levels in 2024 are < 2% of the trawl survey biomass estimate from < 500 m.

Ecosystem Considerations

A determination of ecosystem considerations for grenadiers in Alaska is hampered by the lack of biological and habitat information for these species and limited knowledge on the deep-slope environment inhabited by these fish. There has been virtually no directed fishing for grenadiers in Alaska. Note that because grenadiers do not survive being caught, dead and discarded individuals contribute organic material into the ecosystem that would not otherwise be present.

Literature cited

Alferof, A. I. and D. S. Kurnosov. 2024. Life Cycle Characteristics and Distribution of Giant Grenadier Coryphaenoides pectoralis (Macrouridae) in Northwest Bering Sea. J. Ichthyol. 64: 304–316.

Clausen, D. M. 2008. The giant grenadier in Alaska. *In* A. M. Orlov and T. Iwamoto (Editors), Grenadiers of the world oceans: biology, stock assessment, and fisheries, p. 413–450. Amer. Fish. Soc Sympos. 63.

Clausen, D. M., and C. J. Rodgveller. 2013. Deep-water longline experimental longline survey for giant grenadier, Pacific grenadier, and sablefish, in the western Gulf of Alaska. NOAA Tech. Memo. NMFS-AFSC-247.

Drazen, J. C., T. W. Buckley, and G. R. Hoff. 2001. The feeding habits of slope dwelling macrourid fishes in the eastern North Pacific. Deep-Sea Res. I 48: 909–935.

Gaichas, S. 2003. Squid and other species in the Bering Sea and Aleutian Islands. *In*: Stock assessment and fishery evaluation report for the groundfish resources of the Bering Sea/Aleutian Islands region, November 2003, p. 777–808. North Pacific Fishery Management Council, 605 W. 4th Ave., Suite 306, Anchorage AK 99501.

Hoff, G. R., and L. L. Britt. 2009. Results of the 2008 eastern Bering Sea upper continental slope survey of groundfish and invertebrate resources. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-197, 294 p.

Hoff, G. R., and L. L. Britt. 2011. Results of the 2010 eastern Bering Sea upper continental slope survey of groundfish and invertebrate resources, 300 p.

Iwamoto, T., and D. L. Stein. 1974. A systematic review of the rattail fishes (Macrouridae: Gadiformes) from Oregon and adjacent waters. Occasional Papers of the California Academy of Sciences No. 111, 79 p.

Mecklenburg, C. W., T. A. Mecklenburg, and L. K. Thorsteinson. 2002. Fishes of Alaska. Amer. Fish. Soc., Bethesda, Maryland, 1,037 p.

Novikov, N. P. 1970. Biology of *Chalinura pectoralis* in the North Pacific. *In*: P. A. Moiseev (Editor), Soviet fisheries investigations in the northeastern Pacific, Part V (In Russian). All-Union Scientific Research Institute of Marine Fisheries and Oceanography (VNIRO), Proceedings Vol. 70, and Pacific Scientific Research Institute of Fisheries and Oceanography (TINRO), Proceedings Vol. 72. (Translated by Israel Program for Scientific Translations, Jerusalem, 1972, p. 304–331).

Orlov, A. M., and S. I. Moiseev. 1999. Some biological features of Pacific sleeper shark, *Somniosus pacificus* (Bigelow *et* Schroeder 1944) (Squalidae), in the northwestern Pacific Ocean. Polish Academy of Sciences, National Scientific Committee on Oceanic Research, Institute of Oceanography, University of Gdansk. Oceanological Studies FVIII No. 1–2: 3–16.

Rodgveller, C. J., C. E. Hutchinson, J. P. Harris, S. C. Vulstek, and C. M. Guthrie III. 2017. Otolith shape variability and associated body growth differences in giant grenadier. PLOS ONE doi.org/10.1371/journal.pone.0180020

Rodgveller, C. J. C. R. Lunsford, and J. T. Fujioka. 2008. Evidence of hook competition in logline surveys. Fishery Bulletin 106(4): 354–374.

Rodgveller, C. J., D. M. Clausen, J. J. Nagler, and C. Hutchinson. 2010. Reproductive characteristics and mortality of female giant grenadiers in the northern Pacific Ocean. Mar. Coast. Fish.: Dynamics, Management, and Ecosystem Sci. 2: 73–82.

Rodgveller, C. J., and K. A. Siwicke. 2020. Assessment of the Grenadier stock complex in the Gulf of Alaska, Eastern Bering Sea, and Aleutian Islands. North Pacific Fishery Management Council, Anchorage, AK.

Ronholt, L. L., K. Teshima, and D. W. Kessler. 1994. The groundfish resources of the Aleutian Islands region and southern Bering Sea 1980, 1983, and 1986. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-31, 351 p.

Sullivan, J. Y., C. Monnahan, P. Hulson, J. Ianelli, J. Thorson, and A. Havron. 2022. REMA: a consensus version of the random effects model for ABC apportionment and Tier 4/5 assessments. Plan Team Report, Joint Groundfish Plan Teams, North Pacific Fishery Management Council. 605 W 4th Ave, Suite 306 Anchorage, AK 99501.

Tuponogov, V. N., A. M. Orlov, and L. S. Kodolov. 2008. The most abundant grenadiers of the Russian Far East EEZ: Distribution and basic biological patterns, in Grenadiers of the World Oceans: Biology, Stock Assessment, and Fisheries, Bethesda: Am. Fish. Soc., pp. 285–316.

Walker, W. A., J. G. Mead, and R. L. Brownell, Jr. 2002. Diets of Baird's beaked whales, *Berardius bairdii*, in the southern Sea of Okhotsk and off the Pacific coast of Honshu, Japan. Marine Mammal Science 18(4): 902–919.

Yang, M-S. 2003. Food habits of the important groundfishes in the Aleutian Islands in 1994 and 1997. AFSC Processed Rep. 2003-07, 233 p. (Available from National Marine Fisheries Service, Alaska Fisheries Science Center, 7600 Sand Point Way NE, Seattle WA 98115).

Yang, M-S., K. Dodd, R. Hibpshman, and A. Whitehouse. 2006. Food habits of groundfishes in the Gulf of Alaska in 1999 and 2001. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-AFSC-164.

Tables

Table 1. Updated catch data (t) for grenadiers in the Eastern Bering Sea (EBS), Aleutian Islands (AI), combined Bering and Aleutians (BSAI) and Gulf of Alaska (GOA) as of October 16, 2024.

Year	EBS	AI	BSAI	GOA	Total
1997	2,964	2,887	5,851	12,029	17,880
1998	5,011	1,578	6,589	14,683	21,272
1999	4,505	2,883	7,388	11,388	18,776
2000	4,067	3,254	7,321	11,610	18,931
2001	2,294	1,460	3,754	9,685	13,439
2002	1,891	2,807	4,698	10,479	15,177
2003	2,647	3,034	5,681	10,843	16,523
2004	2,203	1,228	3,431	10,470	13,901
2005	2,641	1,784	4,425	6,606	11,031
2006	2,067	2,224	4,291	8,506	12,797
2007	1,641	1,576	3,217	9,366	12,583
2008	1,687	1,800	3,488	11,113	14,600
2009	2,983	3,680	6,663	6,660	13,323
2010	3,531	4,600	8,131	6,483	14,614
2011	5,517	3,838	9,355	8,589	17,944
2012	3,828	5,457	9,285	8,430	17,715
2013	1,972	3,522	5,494	21,642	27,136
2014	1,192	2,477	3,669	7,612	11,281
2015	1,688	1,002	2,689	8,423	11,113
2016	2,053	1,047	3,100	11,364	14,464
2017	2,103	688	2,791	7,645	10,436
2018	1,106	710	1,816	6,902	8,718
2019	1,530	700	2,230	4,811	7,041
2020	1,366	953	2,319	2,272	4,591
2021	1,454	1,237	2,691	1,112	3,802
2022	1,020	1,091	2,111	952	3,063
2023	982	1,572	2,554	1,013	3,567
2024	428	772	1,199	669	1,868

Table 2. Estimated catch (t) of grenadier in the Eastern Bering Sea by target species/species group as of October 16, 2024, where ATF = arrowtooth flounder, Kam = Kamchatka flounder, GT = Greenland turbot, Halibut = Pacific halibut, Cod = Pacific cod, RF = Rockfish, Sable = sablefish, and Other = all other target species/groups combined. The last column indicates the percentage retained (% Retained).

Year	ATF	Kam	GT	Halibut	Cod	RF	Sable	Other	% Retained
2003	38		1,460	355	245	9	370	165	0.0%
2004	24		1,312	290	238	23	233	83	0.0%
2005	26		1,974	148	344	9	108	31	0.0%
2006	125		1,189	181	127	12	417	16	0.0%
2007	2		1,073	88	179	17	211	70	0.0%
2008	69		708	392	163	3	127	226	0.0%
2009	242		1,823		212	6	692	8	0.0%
2010	315		2,233	201	417	152	212	3	15.3%
2011	863	245	2,328	301	1,272	19	487	2	4.5%
2012	675	6	1,653	600	641	3	227	23	0.0%
2013	272	14	511	592	245	44	292	2	0.0%
2014	121	10	468	205	161	2	214	10	0.1%
2015	112	3	1,026	288	135	4	107	12	0.1%
2016	48	18	1,193	395	317	14	55	13	0.2%
2017	31	62	1,589	47	230	9	106	30	0.3%
2018	8	16	775	42	165	43	34	22	0.0%
2019	128	127	889	46	152	40	74	74	0.1%
2020	59	331	613	43	160	41	44	75	0.3%
2021	293	24	444	13	13	57	161	449	0.0%
2022	134	36	271	14	9	90	91	374	0.4%
2023	257	63	72	3	3	81	304	200	18.7%
2024	14	103	22	29	2	79	160	19	5.0%

Table 3. Estimated catch (t) of grenadier in the Aleutian Islands by target species/species group as of October 16, 2024, where ATF = arrowtooth flounder, Kam = Kamchatka flounder, Atka = Atka mackerel, GT = Greenland turbot, Halibut = Pacific halibut, Cod = Pacific cod, RF = Rockfish, Sable = sablefish, and Other = all other target species/groups combined. The last column indicates the percentage retained (% Retained).

Year	ATF	Kam	Atka	GT	Halibut	Cod	RF	Sable	Other	% Retained
2003			< 1	113	1,374	46	6	1,494	< 1	0.0%
2004				14	424	13	61	716	1	0.0%
2005			14	161	606	2	21	978	2	0.0%
2006	341		< 1	328	175	121	154	1,105	< 1	0.0%
2007	108		36	343	70	41	21	918	40	0.0%
2008	397		274	67	229	26	59	746	2	0.0%
2009	1,377		84	414		12	151	1,642	< 1	0.0%
2010	1,676		214	372	194	316	156	1,671	< 1	1.8%
2011	61	726	113	82	476	< 1	284	2,096		2.5%
2012	264	2,566	424		571	43	45	1,544		0.1%
2013	278	406	210	41	345	3	242	1,995	1	0.0%
2014	254	295	61	< 1	112	23	227	1,505		4.6%
2015	2	169	45		165	3	66	553		0.0%
2016	27	61	95		215		94	554		0.0%
2017		240	60		22	< 1	20	347		0.2%
2018		109	65		46	2	84	404	< 1	1.5%
2019	< 1	181	107		4	< 1	79	329	< 1	0.3%
2020	3	666	69		46	1	141	27	< 1	0.9%
2021	105	679	77		7	15	264	90		0.0%
2022	2	842	37		3	8	154	42	2	0.2%
2023	13	1,251	45		1		207	53		0.3%
2024	155	250	174		2		184	4	3	0.5%

Table 4. Estimated catch (t) of grenadier in the Gulf of Alaska by target species/species group as of October 16, 2024, where ATF = arrowtooth flounder, Halibut = Pacific halibut, Cod = Pacific cod, RF = Rockfish, Sable = sablefish, and Other = all other target species/groups combined. The last column indicates the percentage retained (% Retained).

Year	ATF	Halibut	Cod	RF	Sable	Other	% Retained
2003	27	710	5	613	8,464	1,023	0.0%
2004	171	156	< 1	2,231	7,655	257	0.0%
2005	103	488		212	5,743	60	0.0%
2006	18	766	22	338	7,233	127	0.0%
2007	90	530	79	198	8,439	29	0.0%
2008	3	1,918	97	164	8,597	334	0.0%
2009		1,430	79	227	4,779	145	0.0%
2010	41	364	151	380	5,088	459	2.4%
2011	123	205	60	610	7,186	406	0.7%
2012	209	42	227	416	7,402	135	0.9%
2013	672	694	132	1,006	13,349	5,789	0.3%
2014	439	355	175	556	6,039	48	0.3%
2015	37	477	93	951	6,852	13	0.1%
2016	135	826	86	457	8,957	903	0.2%
2017	97	437	14	1,052	5,979	66	0.2%
2018	< 1	232	< 1	1,696	4,944	29	0.5%
2019	15	398	< 1	758	3,593	47	0.9%
2020	81	17		304	1,820	50	2.3%
2021	2	9	80	252	713	56	5.2%
2022	2	15	48	199	599	88	7.1%
2023	< 1	23	44	154	747	46	4.8%
2024	< 1	10	< 1	88	569	1	0.7%

Table 5. Design-based estimates with coefficient of variation (CV) of Gulf of Alaska (GOA) giant grenadier biomass (t) by management region and depth strata. These are provided by the Alaska Fisheries Science Center GOA bottom trawl survey and used in the random effects model.

Year	WGOA			CGOA			EGOA		
	0–500 m	501–700 m	701–1000 m	0–500 m	501–700 m	701–1000 m	0–500 m	501–700 m	701–1000 m
1990	4,913 (0.331)	-	-	14,573 (0.854)	-	-	708 (0.330)	-	-
1993	34,777 (0.317)	-	-	14,582 (0.446)	-	-	2,053 (0.453)	-	-
1996	34,079 (0.262)	-	-	16,117 (0.275)	-	-	1,160 (0.490)	-	-
1999	40,796 (0.283)	33,509 (0.328)	34,168 (0.500)	72,184 (0.227)	92,333 (0.236)	75,930 (0.218)	10,973 (0.788)	20,778 (0.392)	9,237 (0.272)
2001	69,736 (0.684)	-	-	93,995 (0.321)	-	-	-	-	-
2003	97,499 (0.303)	49,995 (0.239)	-	119,720 (0.325)	71,870 (0.445)	-	8,085 (0.681)	49,732 (0.656)	-
2005	127,792 (0.467)	76,397 (0.450)	36,398 (0.554)	106,077 (0.237)	147,927 (0.153)	48,073 (0.197)	3,335 (0.640)	21,536 (0.236)	19,810 (0.470)
2007	73,850 (0.365)	64,082 (0.362)	40,715 (0.162)	32,836 (0.395)	142,692 (0.197)	99,676 (0.439)	3,208 (0.733)	22,323 (0.540)	8,692 (0.176)
2009	37,266 (0.263)	74,905 (0.428)	73,684 (0.525)	58,846 (0.205)	84,534 (0.274)	366,005 (0.737)	2,568 (0.560)	12,151 (0.169)	8,361 (0.405)
2011	25,383 (0.353)	54,837 (0.463)	-	129,761 (0.374)	63,794 (0.190)	-	1,298 (0.729)	17,070 (0.231)	-
2013	54,218 (0.296)	20,395 (0.407)	-	152,922 (0.288)	88,169 (0.414)	-	7,044 (0.491)	22,815 (0.498)	-
2015	30,237 (0.257)	54,670 (0.327)	23,286 (0.866)	82,321 (0.245)	158,874 (0.264)	91,823 (0.161)	4,113 (0.444)	53,176 (0.466)	39,951 (0.481)
2017	30,237 (0.257)	54,670 (0.327)	-	69,461 (0.284)	43,987 (0.391)	-	713 (1.000)	23,178 (0.355)	-
2019	44,549 (0.110)	12,888 (0.711)	-	67,587 (0.290)	73,206 (0.351)	-	23 (1.000)	18,283 (0.123)	-
2021	50,883 (0.525)	22,351 (0.352)	-	45,129 (0.393)	61,869 (0.304)	-	1,210 (0.864)	2,043 (0.354)	-
2023	17,992 (0.389)	-	-	40,713 (0.351)	34,321 (0.554)	-	1,532 (0.729)	6,901 (0.239)	-

Table 6. Design-based estimates with coefficient of variation (CV) of Eastern Bering Sea giant grenadier biomass (t). These are provided by the Alaska Fisheries Science Center slope bottom trawl survey and used in the random effects model.

Year	Biomass
2002	434,994 (0.096)
2004	686,634 (0.103)
2008	453,935 (0.106)
2010	681,121 (0.102)
2012	556,653 (0.106)
2016	491,277 (0.097)

Table 7. Design-based estimates with coefficient of variation (CV) of Aleutian Islands giant grenadier biomass (t) down to 500-m depth. These are provided by the Alaska Fisheries Science Center AI bottom trawl survey.

Year	Biomass
1991	24,594 (0.342)
1994	33,669 (0.380)
1997	71,501 (0.516)
2000	219,693 (0.686)
2002	218,147 (0.608)
2004	248,158 (0.382)
2006	192,640 (0.572)
2010	70,748 (0.336)
2012	86,556 (0.350)
2014	79,423 (0.479)
2016	172,347 (0.421)
2018	101,332 (0.361)
2022	29,658 (0.387)
2024	41,885 (0.707)

Table 8. Design-based estimates with coefficient of variation (CV) of Gulf of Alaska giant grenadier relative population weight (RPW) by management region. These are provided by the Alaska Fisheries Science Center longline survey and used in the random effects model.

Year	WGOA	CGOA	EGOA
1992	242,459 (0.111)	364,467 (0.076)	44,331 (0.170)
1993	492,173 (0.078)	508,221 (0.134)	69,835 (0.134)
1994	464,299 (0.085)	475,292 (0.120)	60,157 (0.154)
1995	557,182 (0.087)	600,566 (0.092)	87,126 (0.154)
1996	381,187 (0.091)	644,274 (0.120)	65,222 (0.093)
1997	490,905 (0.055)	632,476 (0.065)	107,523 (0.141)
1998	537,911 (0.045)	420,776 (0.092)	102,314 (0.091)
1999	411,200 (0.061)	577,177 (0.075)	114,934 (0.137)
2000	474,387 (0.153)	519,155 (0.119)	118,365 (0.092)
2001	407,115 (0.072)	516,173 (0.162)	111,726 (0.090)
2002	431,508 (0.091)	375,825 (0.115)	81,713 (0.071)
2003	408,811 (0.201)	527,886 (0.126)	89,765 (0.128)
2004	389,601 (0.097)	351,035 (0.115)	61,949 (0.122)
2005	327,935 (0.194)	398,433 (0.087)	81,553 (0.137)
2006	422,019 (0.131)	332,104 (0.138)	84,075 (0.067)
2007	469,377 (0.110)	571,901 (0.117)	149,447 (0.097)
2008	394,112 (0.067)	404,036 (0.101)	105,663 (0.160)
2009	389,087 (0.062)	499,245 (0.108)	119,731 (0.063)
2010	490,303 (0.059)	587,656 (0.092)	96,724 (0.137)
2011	320,970 (0.167)	408,634 (0.104)	81,445 (0.063)
2012	291,709 (0.111)	448,548 (0.128)	105,829 (0.117)
2013	292,015 (0.091)	437,971 (0.105)	100,225 (0.093)
2014	288,765 (0.085)	384,194 (0.119)	108,807 (0.133)
2015	553,974 (0.146)	582,113 (0.070)	81,077 (0.107)
2016	295,072 (0.161)	423,320 (0.115)	72,743 (0.111)
2017	419,712 (0.085)	397,738 (0.165)	79,270 (0.082)
2018	310,408 (0.076)	388,441 (0.112)	65,710 (0.194)
2019	314,624 (0.174)	483,906 (0.078)	94,378 (0.116)
2020	194,109 (0.189)	220,877 (0.123)	57,277 (0.146)
2021	275,333 (0.078)	273,529 (0.166)	76,404 (0.075)
2022	190,550 (0.199)	194,063 (0.195)	41,497 (0.121)
2023	131,032 (0.079)	195,586 (0.063)	41,881 (0.107)

Table 9. Design-based estimates with coefficient of variation (CV) of Gulf of Alaska giant grenadier relative population weight (RPW) for the Eastern Bering Sea (EBS) and Eastern Aleutian Islands (EAI). These are provided by the Alaska Fisheries Science Center longline survey, and the EBS data is used in the random effects model.

Year	EBS	EAI
1996	-	490,466 (0.119)
1997	694,479 (0.083)	-
1998	-	842,141 (0.097)
1999	553,894 (0.104)	-
2000	-	1,076,222 (0.155)
2001	365,624 (0.137)	-
2002	-	1,079,804 (0.149)
2003	542,041 (0.196)	-
2004	-	1,018,826 (0.136)
2005	662,222 (0.144)	-
2006	-	1,210,610 (0.133)
2007	482,205 (0.205)	-
2008	-	699,450 (0.086)
2009	540,924 (0.140)	-
2010	-	1,177,789 (0.093)
2011	580,973 (0.096)	-
2012	-	777,235 (0.214)
2013	616,071 (0.148)	-
2014	-	1,221,138 (0.098)
2015	532,726 (0.142)	-
2016	-	1,105,426 (0.138)
2017	685,214 (0.148)	-
2018	-	779,099 (0.142)
2019	443,809 (0.216)	-
2020	-	567,610 (0.183)
2021	311,876 (0.137)	-
2022	-	444,150 (0.134)
2023	215,116 (0.111)	-

Table 10. Time series of estimated exploitable biomass using the random effects for the Gulf of Alaska with 95% lower (LCI) and upper confidence intervals (UCI).

Year	Biomass (t)	LCI	UCI
1990	345,027	210,809	564,697
1991	349,012	237,918	511,978
1992	354,918	281,218	447,932
1993	452,709	364,651	562,033
1994	484,211	392,366	597,555
1995	536,591	433,212	664,640
1996	518,481	420,184	639,774
1997	535,241	437,627	654,628
1998	497,992	412,420	601,320
1999	471,640	406,487	547,236
2000	487,358	402,584	589,984
2001	475,698	394,632	573,417
2002	449,164	372,286	541,917
2003	463,806	390,302	551,153
2004	432,189	359,069	520,198
2005	474,058	409,471	548,834
2006	444,866	370,961	533,495
2007	486,096	417,982	565,310
2008	449,673	377,424	535,751
2009	462,790	391,300	547,342
2010	479,970	396,275	581,343
2011	425,792	355,291	510,281
2012	416,705	344,030	504,733
2013	430,548	361,301	513,067
2014	423,275	351,116	510,265
2015	493,615	418,953	581,581
2016	412,544	338,990	502,057
2017	397,564	326,206	484,531
2018	369,760	303,932	449,847
2019	361,333	298,540	437,333
2020	279,763	228,287	342,846
2021	271,601	224,648	328,367
2022	219,266	177,350	271,090
2023	191,650	155,985	235,470
2024	191,650	138,084	265,995
2025	191,650	126,510	290,330

Table 11. Time series of estimated exploitable biomass using the random effects for the Eastern Bering Sea with 95% lower (LCI) and upper confidence intervals (UCI).

Year	Biomass (t)	LCI	UCI
1997	666,477	533,076	833,262
1998	599,209	436,994	821,640
1999	538,730	425,515	682,067
2000	470,188	342,505	645,470
2001	410,367	320,819	524,910
2002	447,025	378,718	527,653
2003	533,941	422,658	674,524
2004	639,002	534,449	764,009
2005	620,566	488,498	788,339
2006	560,965	407,823	771,612
2007	507,088	388,224	662,344
2008	482,206	402,429	577,799
2009	542,443	437,245	672,951
2010	630,225	530,316	748,958
2011	580,599	477,986	705,242
2012	566,010	475,540	673,692
2013	578,067	453,885	736,226
2014	552,514	403,691	756,202
2015	528,090	416,622	669,382
2016	511,571	433,131	604,216
2017	566,774	438,146	733,165
2018	490,736	347,733	692,547
2019	424,899	308,635	584,960
2020	361,439	254,662	512,986
2021	307,458	234,248	403,547
2022	262,909	188,248	367,182
2023	224,816	173,185	291,839
2024	224,816	145,919	346,371
2025	224,816	129,347	390,747

Figures

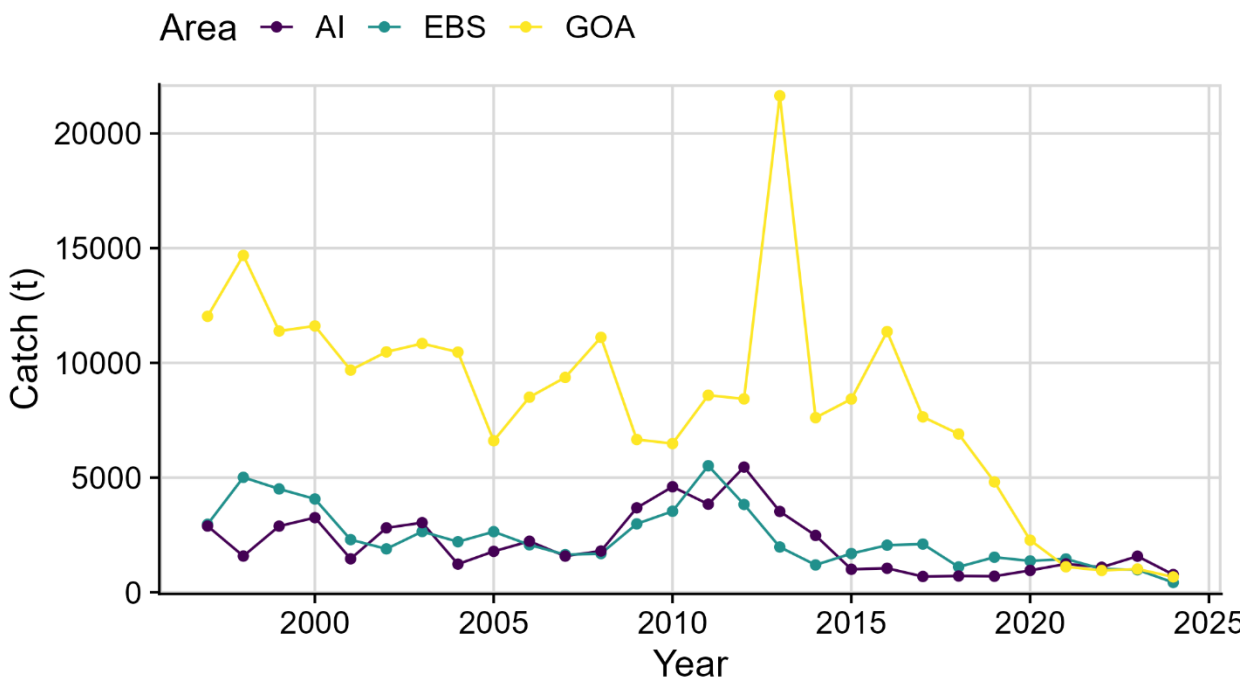

Figure 1. Catch (t) of grenadiers in the Aleutian Islands (AI, purple), Eastern Bering Sea (EBS, green), and the Gulf of Alaska (GOA, yellow). Data are from NMFS Alaska Regional Office Catch Accounting System via the Alaska Fisheries Information Network (AKFIN) database.

Figure 2. Gulf of Alaska giant grenadier random effects model (REMA) results (solid lines with 95% confidence intervals in shaded regions) Model 24 (purple). Fits are to design-based survey estimates from the Alaska Fisheries Science Center bottom trawl survey (BTS, biomass by region and depth strata, 9 panels on the left) and longline survey (LLS, relative population weight, 3 panels on the right), where filled black circles are design-based estimates with error bars for the 95% confidence intervals.

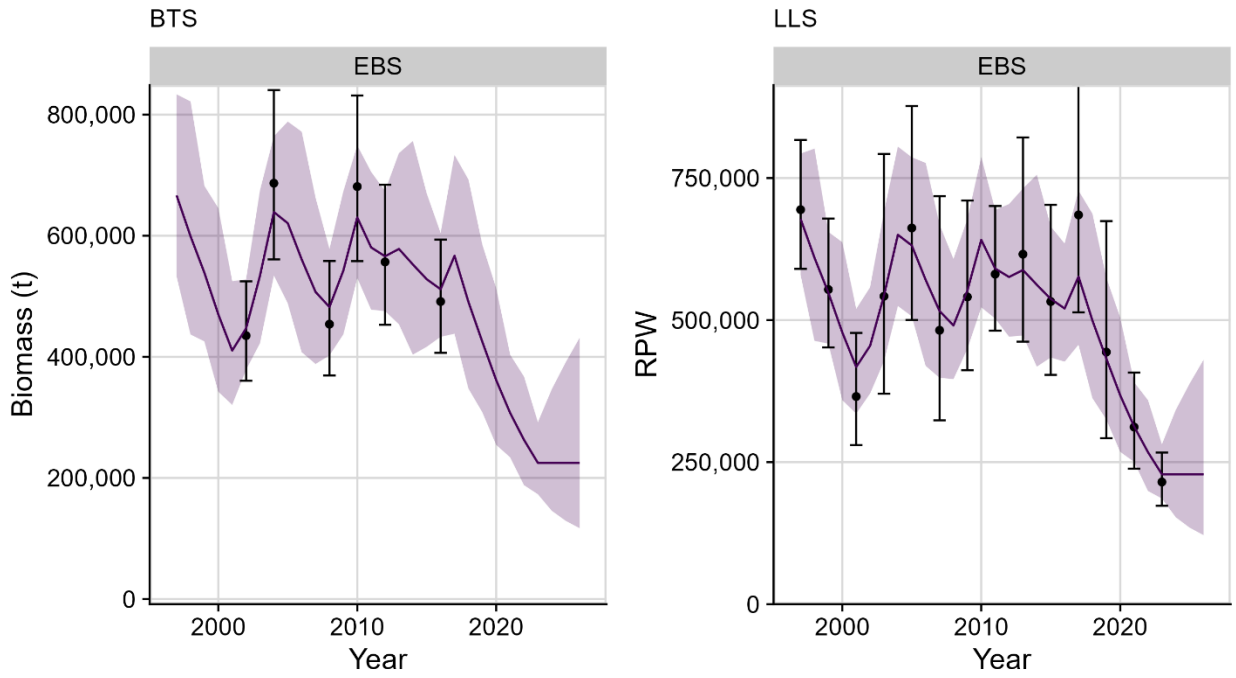

Figure 3. Eastern Bering Sea giant grenadier random effects model (REMA) results (solid lines with 95% confidence intervals in shaded regions). Fits are to design-based survey estimates from the Alaska Fisheries Science Center slope bottom trawl survey (BTS) biomass (left) and longline survey (LLS) relative population weight (RPW, right), where filled black circles are design-based estimates with error bars for the 95% confidence intervals.

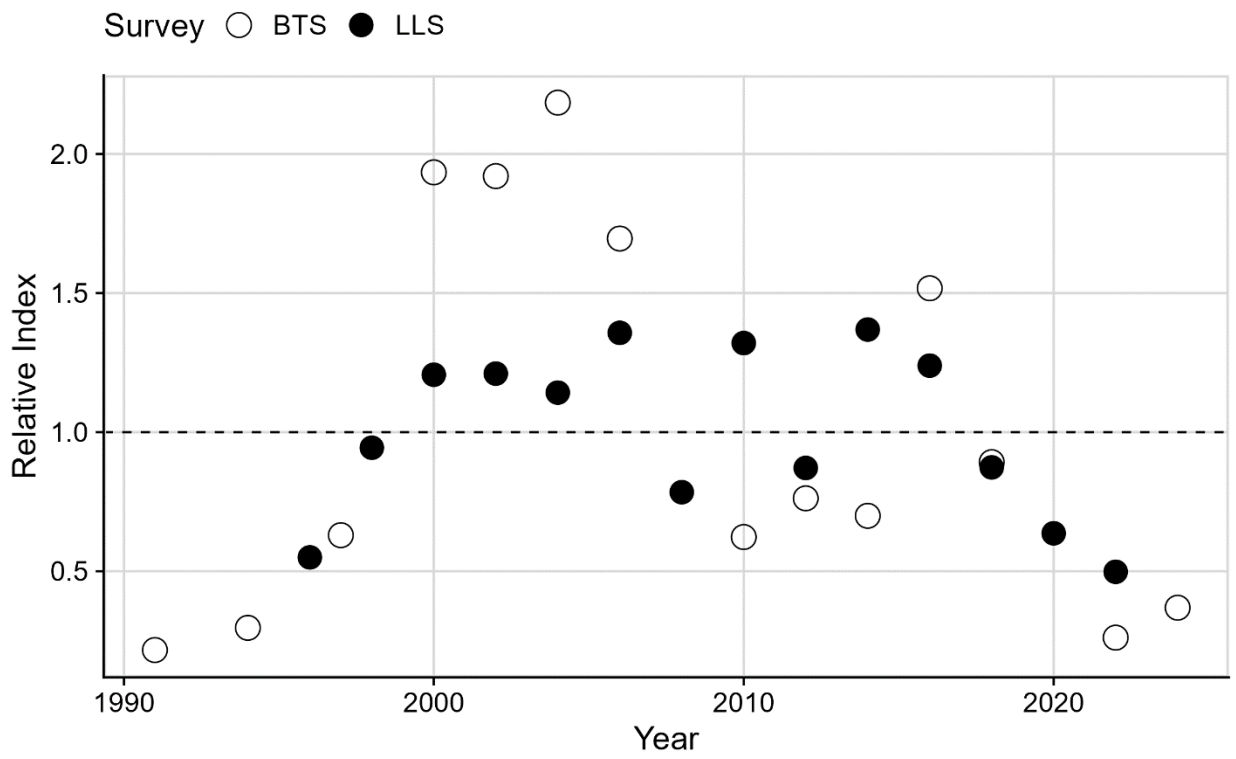

Figure 4. Relative indices of biomass from bottom trawl survey (BTS, open circles) biomass estimates (t) of giant grenadier in less than 500-m depth from the Aleutian Islands, and longline survey (LLS, filled circles) relative population weight in the eastern Aleutian Islands.

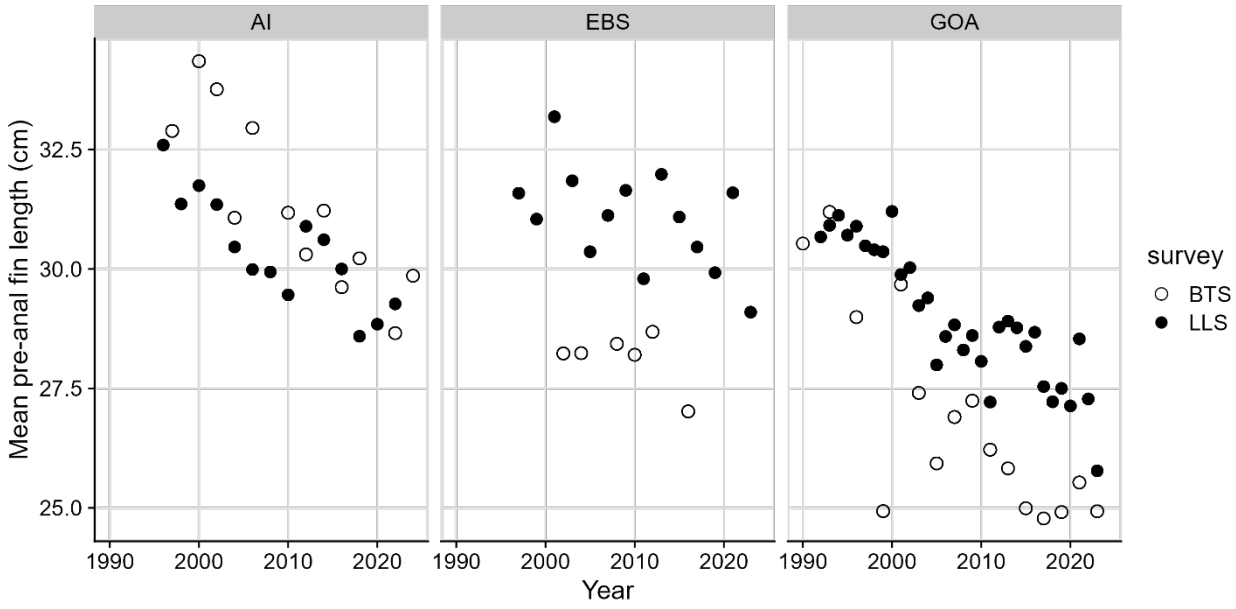

Figure 5. Mean length of giant grenadier by survey, year, and area for the Eastern Aleutian Islands (AI), Eastern Bering Sea (EBS), and the Gulf of Alaska (GOA). Provided by the Alaska Fisheries Science Center bottom trawl survey (BTS, open circles) and longline survey (LLS, filled circles).

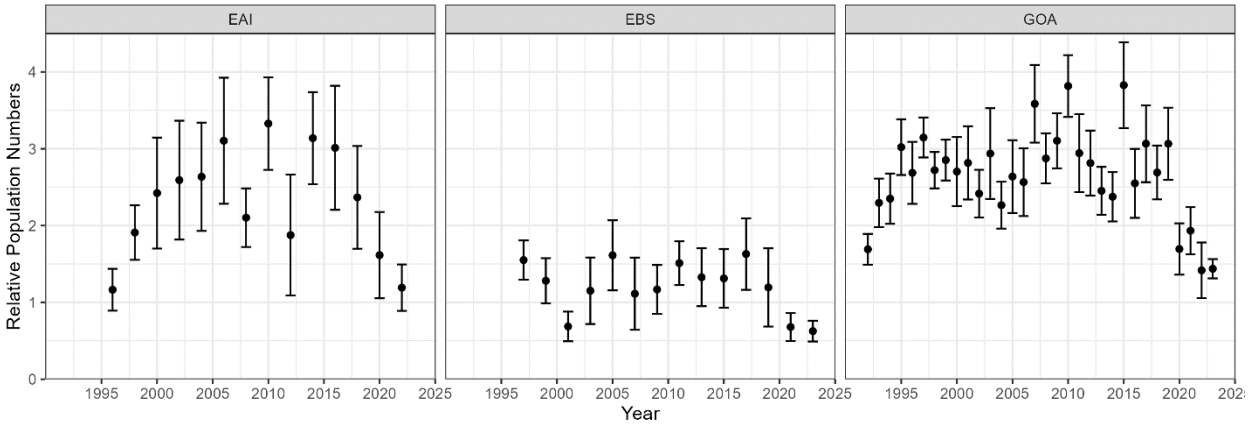

Figure 6. Relative population number estimates of giant grenadier for the Eastern Aleutian Islands (EAI), Eastern Bering Sea (EBS), and the Gulf of Alaska (GOA), with 95% confidence intervals (error bars). Provided by the Alaska Fisheries Science Center longline survey.

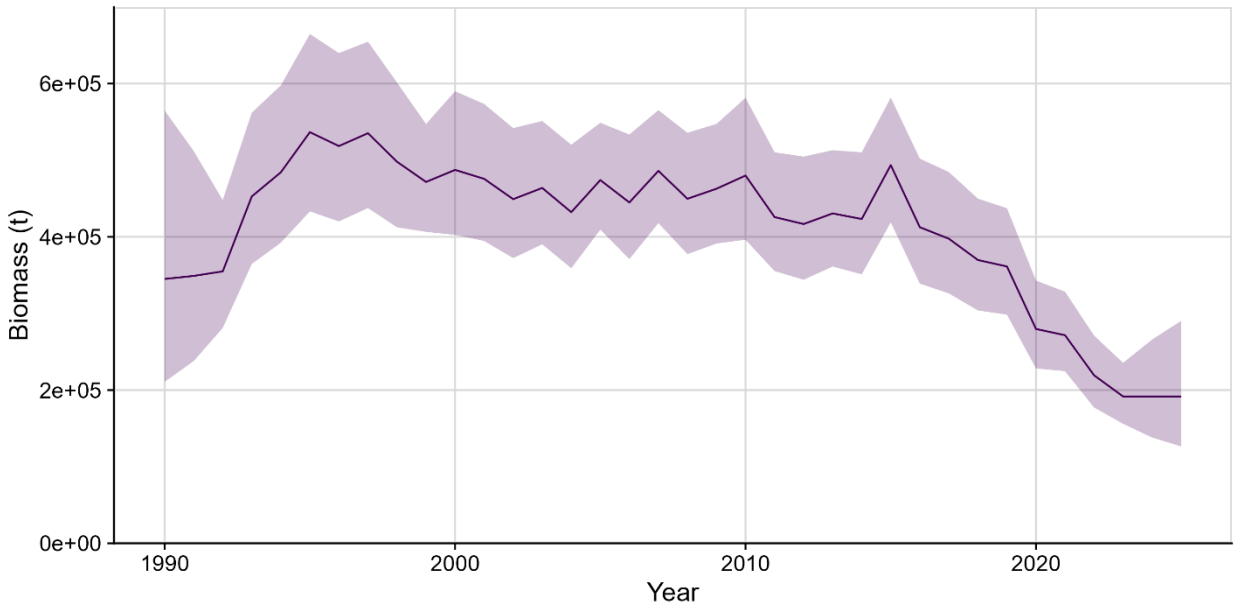

Figure 7. Gulf of Alaska giant grenadier random effects model (REMA) results (solid line with 95% confidence interval in shaded region). REMA was fit to Gulf of Alaska bottom trawl estimates of biomass and longline survey estimates of relative population weights of giant grenadier

Appendix A

Table A-1. Research catch (t) of grenadier where estimates from IPHC survey and "other" sources only available since 2010.

Year	IPHC	AFSC Trawl	AFSC LLS	Total BSAI	IPHC	AFSC Trawl	AFSC LL	Total GOA	Total
1981		66		66		3		3	69
1982		124		124		0		0	124
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	133	136	136
1991		10		10			110	110	120
1992							100	100	100
1993						6	122	128	128
1994		6		6			133	133	139
1995							198	198	198
1996			38	38		8	175	183	221
1997		9	79	88			162	162	250
1998			67	67		12	146	158	225
1999			57	57		47	159	206	263
2000		118	89	207			163	163	370
2001			42	42		11	164	175	217
2002		23	83	106			131	131	237
2003		91	50	141		27	153	180	321
2004		196	78	274			111	111	385
2005			71	71		49	122	171	242
2006		20	77	97			114	114	211
2007			79	79		44	167	211	290
2008		123	46	169			121	121	290
2009			88	88		39	156	195	283
2010	9	156	67	232	6		167	173	405
2011	7		75	82	2	20	125	147	229
2012	5	135	42	182	2		134	136	318
2013	5		87	92	2	20	134	156	248
2014	16	79	75	170	2		130	132	302
2015	6		82	88	5	34	157	196	284
2016	9	130	70	209	2		132	134	243
2017	22		92	114	2	7	139	147	261
2018	2	6	45	53	3		104	107	160
2019	6		71	77	5	11	131	147	224
2020	< 1		38	38	< 1		87	87	125
2021	2		55	56	1	8	97	106	162
2022	9	3	20	32	< 1		62	62	95
2023			27	27	<1	3	55	58	85