

this case would not influence fishing behavior, and management of non-target species would not tend to influence the Council's management goals (discards being an exception). In this type of scenario the overall fishery management goals the Council has specified for the fishery would tend to be unaffected. In this instance, an EC classification may be more appropriate².

Other factors that ought to be considered include the role of a species in the ecosystem and the level of catch that is occurring. In other words, we recommend that a two part question be asked—does the species play an important role in the ecosystem? If so, is catch large enough that fishing activity may be having an impact on the food-web via catch of this species? The factors that may lead one to conclude that there is an ecosystem-related reason for considering a species as an EC is not immediately clear from the guidelines, however we can imagine several reasons why classifying as an EC makes sense, which include but are not limited to:

- Prey species: A key prey species may be important to the status and productivity of other species in the marine food web
- Predator species: A key predator may be in a position of causing rippling effects through the food web if their abundance changes
- A large component of biomass: A species might not be a key predator or prey, but by its very abundance it constitutes an important piece of the marine food web

Grenadier Life History and its Role in the Slope Ecosystem

Grenadiers tend to be long-lived species that inhabit the relatively deep reaches of the continental slope. Of the three species being considered for placement in the GOA and BSAI groundfish FMPs, Giant grenadier are estimated to live up to 56 years³, Pacific grenadier are estimated to live up to 73 years⁴, and Popeye grenadier are estimated to live up to 10 years⁵.

Grenadiers are believed to make up a significant portion of the biomass on the slope. Giant grenadiers in particular are considered the dominant species (in terms of total biomass) at depths of 400 to 1,000 m and are therefore likely to play an important ecological role in this area. Pacific and Popeye grenadiers appear to be more abundant at depths that are deeper than those inhabited by Giant grenadier and also

² In the case of Giant grenadiers in the North Pacific, some exploratory activity has occurred in the past which would be considered target activity. We believe that periodic exploratory activity should be expected as part of fishing activity, and indeed we believe it should be encouraged in many instances, however periodic exploratory activity should not lead one to conclude that a species should be classified as "in the fishery". The type of target activity that should lead one to consider classifying a stock as "in the fishery" should be a sustained target activity that exists over time and is likely to continue in the future.

³ Burton, E.J., 1999. Radiometric age determination of the Giant grenadier (*Albatrossia pectoralis*) using ²¹⁰Pb: ²²⁶Ra disequilibria. MS thesis, San Francisco State University

⁴ Andrews, A.H., G.M. Cailliet and K.H. Coale, 1999. Age and growth of the Pacific grenadier (*Coryphaenoides acrolepis*) with age estimate validation using an improved radiometric ageing technique. *Can. J. Fish. Aquat. Sci.* 56:1339-1350.

⁵ Fadeev, N.S., 2005. Guide to biology and fisheries of fishes of the North Pacific Ocean. Vladivostok, TINRO-Center. 366 p.

generally beyond the depths of fishing activity. Furthermore, Popeye grenadier appear too small to be caught by longline gear to any appreciable degree.

Grenadier Stock Status and Catch

Current grenadier biomass estimates suggest a robust and stable stock. In fact, available data tends to demonstrate an increasing trend in biomass, especially if the 1999 biomass estimate is included⁶. Furthermore, available information indicates that overfishing is not occurring and that the stock is not overfished – this being the case without any current measures for conservation and management. The table below summarizes information on the estimated “overfishing level” and the average catch over the 2006 – 2012 time period. On average, estimated catch has been around 6% of the OFL in the Bering Sea and roughly 14% of the OFL in the GOA.

Stock	OFL	'06-'12 average catch	Avg. catch as a % of OFL
GOA Grenadiers	46,635	6,367	13.7%
BSAI Grenadiers	89,878	5,607	6.2%

Note: while there is some uncertainty regarding current and future catch estimates due to recent the changes in the observer program, even a doubling of the catch estimate as a result of these new observer data would result in catch rates that are a small portion of the OFL

The Grenadier biomass estimates are likely biased low. All of the biomass estimates are derived from longline and trawl surveys conducted in both GOA and BSAI at depths shallower than 1,000 m and no adjustment or correction is made to include the portion of the population dwelling below this depth in the total biomass estimate. This means that the current biomass estimate should be considered a minimum estimate, and the impact of the current catch levels in both areas is likely less than is currently being assessed.

Indication that the stock is under-assessed is derived from information showing an increase in the male component in the samples at progressively increasing depth. Based on these data, it is reasonable to assume that some level of sexual disaggregation of the population is occurring and that a significant number of males may not be susceptible to capture in the surveys because they reside at depths below survey depths. Table 1-9 of the December 2012 GOA Grenadier Assessment (Gulf of Alaska and Bering Sea/Aleutian Islands SAFE) shows the male proportion in the survey samples increasing by at least 10% between the 200 m-300 m and 800 m-1,000 m depth strata for the 2006-2012 surveys. Assuming a true 50:50 male:female population sex ratio and not accounting for the male component at depths greater than 1,000 m, the GOA Grenadier biomass estimate could be underestimated by over 45% in GOA and 51% in BSAI. As the following table shows, even if the sex ratio is heavily weighted toward females (as is the case for some species of flatfish) the biomass estimate in the GOA could still be underestimated by 1.3% at 20% males to 27% at 40% males and 4% to 51% in the BSAI, respectively. This is further supported on page 702 of the 2012 Grenadier Assessment, *“In the longline survey sex distributions, there was a trend toward an increased number of males in progressively deeper strata, but even at the*

⁶ Table 1-4 of the December, 2012 GOA Grenadier Assessment, Gulf of Alaska and Bering Sea/Aleutian Islands SAFE

deepest stratum of 800-1,000 m, males were only 6-13% of the catch in the GOA, 7-31% in the eastern AI, and 5-8% in the EBS (Table 1-9). These results imply that much of the male population may reside in depths >1,000 that are not covered by the survey, at least during the summer period when the survey is occurring.”

In the table below we have outlined some approximations of grenadier biomass, OFL, and ABC based on the current assessment and alternative assumptions regarding the true proportion of males in the grenadier population. As assumptions regarding the proportion of males in the population increases, the total estimate of grenadier biomass increases. This is because the majority of males (and also some females) appear to live at depths that are not surveyed.

Table 1 Biomass, OFL, and ABC Estimates Based on Several Possible Scenarios of Male Grenadier Abundance

GOA								
		% > Current Biomass			Avg % Males Observer	Avg. GOA Catch	Catch As	Catch As
	Biomass	Est.	OFL	ABC	'07-'12	'06-'12	% OFL	% ABC
<1,000m 2012-13	597,884		46,635	34,976	18.7%	6,367	13.7%	18.2%
Tot Biomass w/males=20%*	605,759	1.3%	47,249	35,437	20%**	6,367	13.5%	18.0%
Tot Biomass w/males=30%*	674,052	12.7%	52,576	39,432	30%**	6,367	12.1%	16.1%
Tot Biomass w/males=40%*	759,700	27.1%	59,257	44,442	40%**	6,367	10.7%	14.3%
Tot Biomass w/males=50%*	870,282	45.6%	67,882	50,912	50%**	6,367	9.4%	12.5%
BSAI								
		% > Current Biomass			Avg % Males Observer	Avg. BSAI Catch	Catch As	Catch As
	Biomass	Est.	OFL	ABC	'07-'12	'06-'12	% OFL	% ABC
<1,000m 2012-13	1,152,284		89,878	67,409	16.1%	5,607	6.2%	8.3%
Tot Biomass w/males=20%*	1,199,047	4.1%	93,526	70,144	20%**	5,607	6.0%	8.0%
Tot Biomass w/males=30%*	1,338,309	16.1%	104,388	78,291	30%**	5,607	5.4%	7.2%
Tot Biomass w/males=40%*	1,514,171	31.4%	118,105	88,579	40%**	5,607	4.7%	6.3%
Tot Biomass w/males=50%*	1,743,244	51.3%	135,973	101,980	50%**	5,607	4.1%	5.5%
*Tot. Biomass all depths								
**Assumed % Males In Tot. Pop.								

Naturally, one may be inclined to point out that current catch levels are likely to be comprised of females if females do tend to inhabit shallower depths than males. In some cases a high proportion of females in the catch may be cause for concern; however available data does not appear to indicate that there is reason for concern in this case. Catch levels are a small fraction of the total OFL and are so small that it seems unlikely that there is a possibility of overharvesting the female portion of the population. Secondly, if excessive harvest of females was occurring, we would expect to see some evidence in the available data: the proportion of males may begin to increase at shallower depths, the overall catch rate would be decreasing, the survey index of biomass in the shallower depths where females are found would be decreasing, or some combination thereof. None of those phenomena appears to be occurring.

Grenadier Catch Rates and their Correlation with Sablefish Efforts

Grenadier catch rates have remained low relative to the OFL for many years. The catch that does occur is correlated to a fairly high degree with the sablefish longline catches. In other words, inter-annual changes in grenadier catch can be explained – to a large degree – by changes in sablefish longline catch and effort. To demonstrate this point, we regressed grenadier catch on sablefish catch and discovered a high degree of explanatory power between the two in both management areas, as shown in the table below. This means that as sablefish catches increase, grenadier catches should be expected to increase and vice versa.

This information is useful as supporting empirical evidence showing that grenadier catch is incidental to other types of fishing activity and is not the result of targeting activity. Of course, sablefish catch doesn't explain all of the variation in the catch of grenadier. Other contributing forces are undoubtedly the relatively deep-water longline and trawl turbot fishery as well as variations in grenadier abundance, among others.

Table 2 Linear Correlation between Sablefish and Grenadier Catch in the GOA and BSAI (2003 to 2012)

	GOA Grenadier Catch	BSAI Grenadier Catch
GOA Sablefish Catch	0.74	
BSAI Sablefish Catch		0.72

Note: R square values were 0.62 for the GOA and 0.53 in the BSAI

Marketing Efforts

In a June 2012 NPFMC discussion paper addressing grenadier fisheries in the BSAI and GOA⁷, the authors comment that “*there may be potential for future development of a targeted fishery for Giant grenadier.*” They note that there have been “*experimental attempts to market the fish, and there has been food technology research to develop marketable products from this species.*” While true, efforts to market these species have largely been unsuccessful and there is little evidence to suggest that anyone is actively targeting or topping-off the species in either the BSAI or GOA for the purposes of sale or personal use.

One member company of the Freezer Longline Coalition that participates in the BSAI sablefish and turbot fisheries has sometimes opted to retain limited amounts of grenadier. The company sought to market H&G grenadier in domestic and international markets. However, despite their efforts, they have never succeeded in developing a viable market for the fish. They have had no sales of H&G grenadier for nearly two years, and have since stopped retaining even limited quantities of grenadier bycatch. Reasons the company cited for the lack of a market for the species included the poor taste and texture of the fish, and the difficulty of catching grenadier that were large enough in size to attract even some interest from potential buyers.

⁷ *Inclusion of Grenadiers in the Fishery Management Plans For the Bering Sea and Aleutian Islands and/or the Gulf of Alaska*, by Tom Pearson, Sustainable Fisheries, Alaska Region, NMFS; Dave Clausen, AFSC; Jane DiCosimo, NPFMC; June 2012

Research conducted on grenadier fisheries suggests that the company's experience with Giant grenadier is consistent with others fishing in Alaskan waters and elsewhere. The Monterey Bay Aquarium's Seafood Watch report on grenadier⁸ notes that "*Giant grenadier has been considered a valuable food species because of its presumed abundance and the high vitamin and fat content of its liver and eggs. Nevertheless, this species has not received favorable reviews for human consumption. When tested by a panel of judges, Giant grenadier received low scores for flakiness, chewiness, hardness, and fibrousness, and high scores only for moistness* (Matsui et al. 1990)." The report goes on to note that in the early years of the grenadier fishery Japanese fleets caught grenadier for use in surimi. However, while Pacific grenadier produced good surimi, Giant grenadier did not and soon other species replaced grenadier in the Japanese surimi market. Today, fish surimi production worldwide is predominantly derived from Alaskan pollock and other species, with little, if any production from grenadier species.⁹

Worldwide, several species identified as grenadiers are, or have been successfully harvested for commercial sale. However, it's important to point out that several of these species are vastly different in a biological sense from Giant grenadier (some of them are Merlucciidae while Giant grenadier are Macrouridae). Others have noticeably different qualities that make them more viable on the commercial market. Pacific grenadier has been marketed and sold on the West Coast, off of California (though landings there are small, totaling just over 14 tons in 2012 at \$0.10 per pound). Likewise, there is a strong commercial fishery in Australia and New Zealand for Blue grenadier, also known as hake. These species differ from Giant grenadier in that they are known to have a taste, color and texture that is much more appealing for human consumption than Giant grenadier. Other harvested species identified as grenadiers, but which are distinct from Giant grenadiers, include roundnose grenadier (North Atlantic), Patagonian grenadier (South America) and roughnose grenadier (North Atlantic), amongst others. At this point in time a future fishery for Giant grenadier should only be considered a hypothetical scenario, and one which would require technological advancements in order to create a product that is desirable to the human palate.

The Future

As we consider the future environment that will influence fishing activity in the North Pacific and impact the corresponding levels of grenadier catch, it is helpful to consider a few points:

- We believe it is unlikely that a market for Giant grenadier will develop in the foreseeable future. Such a development would require an innovation in food science technology to create a product that is appealing to the human palate. We are unaware of any imminent breakthroughs in such technology and therefore the prospect of a target fishery seems hypothetical at best.
- The Council is considering measures to deal with whale depredation issues in the GOA. Should the Council elect to allow pot gear usage in the GOA sablefish fishery, we should expect

⁸ *Seafood Watch Seafood Report: Grenadier, West Coast Region*; by Kelsey Abbott, on behalf of Monterey Bay Aquarium; updated March 17, 2006

⁹ Aside from Alaskan pollock, other species cited by Monterey Bay Aquarium as used in fish surimi include Atka mackerel, barracuda, blue whiting, cod, hoki, mackerel, Pacific whiting, sardine, striped mullet and threadfin bream. See http://www.montereybayaquarium.org/cr/SeafoodWatch/web/sfw_factsheet.aspx?fid=17

grenadier catch rates to decline there. Bering Sea observer data indicates that pot gear catches far fewer grenadier than longline gear.

Together, these issues indicate that the direction of grenadier catch levels in the GOA and BSAI should remain relatively stable, and perhaps even decline in the foreseeable future. As indicated previously, existing catch levels are a small fraction of the OFL. This provides additional rationale for not classifying grenadiers as “in the fishery”.

Concluding Remarks

When we combine the best available scientific information and policy guidance on the content of Fishery Management Plans, we believe that designating grenadiers as “in the fishery” would be inappropriate. It is not apparent that classifying them as such would result in any conservation outcome, but it would clearly have negative impacts, both economic and managerial.

Available information shows that grenadiers are not subject to overfishing and are not overfished; the biomass of grenadiers has generally been increasing over the past couple of decades; targeting of grenadiers does not currently take place and what limited retention has taken place is best described as “exploratory” in nature as companies explore market possibilities. To date these market exploration activities can only be considered a failure and the prospect of a Giant grenadier market developing in the near future is best described as a hypothetical scenario.

There may be reasons for placing grenadiers in the FMP so that their status and role in the ecosystem can be monitored more accurately than they are now. Information suggests that grenadiers play an important role in the slope ecosystem due to their abundance there and – to the naked eye – catch volumes could be large enough to warrant some monitoring of these effects, even though catch rates are far below the OFL.

For these reasons, and others listed above, we believe it would be reasonable to leave grenadiers outside both the BSAI and GOA groundfish FMPs entirely. However, we recommend that Giant grenadiers be placed in the GOA and BSAI Groundfish FMPs and classified as “Ecosystem Component” species due to their apparent ecological importance on the continental slope. We envision the purpose for classifying them in this way is to primarily serve as a monitoring function and would not lead to the establishment of Annual Catch Limits. We do not believe the information supports the placement of Pacific or Popeye grenadier within either FMP as the available information indicates these species are largely outside the reach of existing fishing activity.