Consumptive Removals of Butterfish by Marine Mammals

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Additional TOR 2: Evaluate consumptive removals of butterfish by its predators, including (if possible) marine mammals, seabirds, tunas, swordfish and sharks. If possible, integrate results into the stock assessment.

Consumptive removals by marine mammals:

In 2015, Smith et al. reported consumption of prey groups by marine mammals on the Northeast US continental shelf, but butterfish were grouped with a number of other miscellaneous fish. In this report, butterfish consumption was estimated as a separate prey category. The proportion of the diet composition comprised of butterfish was calculated using all references from Smith et al. (2015) that included species level of prey resolution and were from samples within butterfish geographic ranges (Ampela 2009, Boulva 1979, Bowen et al. 1993, Bowen and Harrison 1994, Bowen and Harrison 1996, Bowen and Harrison 2007, Craddock and Polloni 2009, Ferland 1999, Hammill et al. 2007, Hammill and Stenson 2000, Mohn and Bowen 1996, Murie and Lavigne 1992, Selzer et al. 1986, Williams 1999), plus four additional publications on marine mammal diets (Beck et al. 2007, Lerner et al. 2018, Flanders et al. 2020, Orphanides et al. 2020). Butterfish averaged 0.06% of gray seal diets and 0.2% of harbor seal diets and were absent from the other 10 species of marine mammal diets (Table 1).

Table 1. Proportion of butterfish in the diets of marine mammals found on the Northeast US continental shelf.

	Butterfish as Proportion of Diet Composition:		
Predator	**Min**	**Mean**	**Max**
Harbor seal	0	0.00192	0.011
Gray seal	0	0.00056	0.016
Harbor porpoise	No butterfish recorded in diet		
Humpback whale	No butterfish recorded in diet		
Fin whale	No butterfish recorded in diet		
Sei whale	No butterfish recorded in diet		
Minke whale	No butterfish recorded in diet		
Right whale	No butterfish recorded in diet		
Pilot whales	No butterfish recorded in diet		
Bottlenose dolphin	No butterfish recorded in diet		
Atlantic white-sided dolphin	No butterfish recorded in diet		
Common dolphin	No butterfish recorded in diet		

In order to put these butterfish removals by marine mammals into context for stock assessment, methods described in Smith et al. (2015) were used to estimate total butterfish consumption by marine mammals and relative butterfish mortality due to marine mammal predation (Table 2). Total annual consumption (*C*) by marine mammals (Table 2) was calculated as:

$C = Y*365*Abundance*Res_{adj}$

Where *Y* is the daily per capita consumed biomass (specific to marine mammal species, Table 2 in Smith et al. 2015), 365 are days in a year, *Abundance* is the most recent population estimate of the marine mammal species (Hayes et al., 2020), and Res_{adj} is the residency ratio including the portion of the marine mammal population occupying the Northeast US shelf, reduced by the portion of feeding that occurs outside of the region due to migration (Table A3 in Smith et al. 2015). Total annual consumption by marine mammals were then multiplied by the proportion of butterfish in the diet of each marine mammal species to estimate annual butterfish consumption (Table 2). The sum of annual butterfish consumption across marine mammals was then divided by the mean of the annual butterfish catches in the marine mammal assessment years to show the ratio of butterfish predation from marine mammals to catch (Table 2).

Table 2. Estimates used to calculate annual butterfish consumption by marine mammals and the ratio of butterfish consumption to butterfish catch.

Predator	Population Estimate Year	Annual Consumption (mt)	Mean Proportion of Butterfish in Diet	Annual Butterfish Consumption (mt)	Annual Butterfish Catch during MM Assessment Year
Harbor seal	2012	83,038	0.00192	159.1	1636
Gray seal	2016	59,417	0.00056	33.1	2731

	Annual Butterfish Consumption by Marine Mammals (mt)	Ratio of Butterfish Consumption by Marine Mammals to Annual Catch
Total	192.2	0.088

Conclusions of Butterfish Consumption by Marine Mammals:

Butterfish appears to be a minor diet component for marine mammal species on the Northeast US continental shelf, likely contributing 0-0.2% of their diets (Table 1). Since butterfish have small otoliths, that may digest at a faster rate than some other finfish and shellfish prey with robust hard parts (deSilva and Neilson 1985), it is possible that butterfish could be underestimated in marine mammal diets. However, Beck et al. (2007) used quantitative fatty acid signature analysis which provides a longer-term index of diet, and does not rely on hard part analysis. Beck et al. (2007) did not find evidence of butterfish predation by gray seals, indicating a low occurrence of butterfish in gray seal diets. Likewise, the estimated 192 mt of annual removals of butterfish by marine mammals is not likely a significant source of mortality, and is on the order of 9% of annual butterfish catch (Table 2). Adams et al. (2015) estimated butterfish biomass losses from natural mortality to be 220,107 mt per year, indicating that marine mammal consumption is a low component of butterfish natural mortality (on the order of 0.09%). However, Suca et al. (2021) cautions that climate projections indicate that sand lance will likely decline in the Northeast US region, and predators including fish and marine mammals may increase prey consumption on butterfish and other small pelagics in the future. Currently sand lance average around 25-35% of harbor seal and gray seal diets respectively (Smith et al, 2015).

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