9. Megabenthos - Filterers

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Background

Although not strictly defined in terms of size, the largest benthic invertebrates are often referred to as “megabenthos”. For the purposes of this modeling exercise, we defined megabenthos filter feeders to include three species of large, commercially exploited bivalves: ocean quahog, *Arctica islandica*; Atlantic surf clam, *Spisula solidissima*; and sea scallop, *Placopecten magellanicus*. Other kinds of bivalves, including mussels (e.g., *Mytilus edulis* and *Modiolus modiolus*), numerous species of small clams, cockles, jingle shells, and others are included in the macrobenthos (polychaetes, crustaceans, mollusks, and others) node (Section 8 of this document).

The ocean quahog is a large, temperate to boreal, infaunal clam with an amphi-Atlantic distribution (Weinberg 1995). It is widely distributed across the continental shelf in medium- to fine-grained sand from the Delmarva Penninsula to Georges Bank (Cargnelli *et al.* 1999a), including nearshore waters in the Gulf of Maine (Wigley and Theroux 1998). It has low recruitment and slow growth rates (Kennish *et al.* 1994; Kennish and Lutz 1995). The Atlantic surf clam is another large infaunal clam found in fine sand to gravel, ranging from the Gulf of St. Lawrence to Cape Hatteras (Merrill and Ropes 1969; Cargnelli *et al.* 1999b). The sea scallop is an epifaunal bivalve living in coarse gravelly or shelly sand to gravel and rock, whose range is similar to that of the surf clam. Sea scallops are moderately abundant only in nearshore waters in the Gulf of Maine (Packer *et al.* 1999).

Data Sources

Fisheries independent survey data from the NEFSC Clam and Scallop Surveys were used to estimate biomass density (g meat weight m^{-2}). The surveys do not sample in the Gulf of Maine (GOM) since biomass densities are low for the three species of bivalves in this node outside state waters in this region. Therefore, data for the GOM subregion was derived from grab sample values (Theroux and Wigley 1998).

Quantitative Approach for Biomass Estimates

Ocean Quahogs and Atlantic Surfclams

Survey data from the NEFSC Clam Surveys for 1997 and 1999 were used to estimate biomass densities of ocean quahogs and Atlantic surfclams in each EMAX region. For each tow, reported shell lengths were converted to meat weights using species- and region-specific length-meat weight regressions (Table 9.1; NEFSC 2003, 2004). Total meat weight caught in a tow was calculated by summing over the individual weights for each species. Area-stratified mean catch per tow was then calculated for each EMAX region and species combination using the total meat weights from stations in survey strata contained within the EMAX region. Efficiency-corrected estimates of species biomass density in EMAX region r and survey year y, d_{ry} (g meat weight m^{-2}), were calculated from the corresponding area-stratified mean catch per tow, c_{ry}, using the formula

(EQ. 9.1) $$d_{ry} = \frac{A_s}{A_r}\frac{d_s}{\bar{d}}\frac{c_{ry}}{a_s\,\varepsilon}$$

where A_r is the area corresponding to EMAX region r; A_s is the area of the sampled survey strata within the EMAX region; d_s is the standard tow distance; $\bar{d}$ is the average tow distance; a_s is the area swept during a standard tow; and ε represents the efficiency of the gear (Table 9.2).

The last ratio in Equation 9.1 is the typical expansion of catch per tow to efficiency-corrected biomass density. The first two terms apply corrections for differences between (1) the sampled survey area and the EMAX region, and (2) distances of a "standard" tow and an average tow. Although strata covering the entire continental shelf are defined for the surveys, typically not all strata are sampled during a survey. Strata where clams are known (or assumed) to be absent are not sampled by the survey. Consequently, survey-based estimates of biomass density will be higher than appropriate for an EMAX region (Tables 9.3 and 9.4). The factor A_s/A_r corrects for this inflation by scaling the biomass density derived from sampled survey strata to an entire EMAX region. Similarly, the factor of $d_s/\bar{d}$ corrects for relative bias due to differences in tow distance between a "standard" tow (upon which area swept, a_s, is based) and an average tow.

Finally, estimates of average biomass density for each EMAX region, d_r, were obtained by averaging the d_{ry} over the individual surveys.

<u>Sea Scallops</u>

Survey data from the NEFSC Scallop Surveys for 1996-2000 were used to estimate biomass densities of sea scallops in each EMAX region. For each tow, reported shell heights were converted to meat weights using region-specific length-meat weight regressions (Table 9.5; NEFSC 2001). In addition, a length-specific correction for gear selectivity between lined and unlined scallop dredges was included prior to calculating total meat weight. Total meat weight (in grams) caught for a given tow was calculated by summing over the individual selectivity-adjusted meat weights, as in

(EQ. 9.2) $$W = \sum_i \left[\frac{0.7148\, e^{0.9180\cdot 0.7148\cdot((160-L_i)-106.3091)} + e^{0.9180\cdot((160-L_i)-106.3091)}}{e^{0.9180\cdot 0.7148\cdot((160-L_i)-106.3091)} + e^{0.9180\cdot((160-L_i)-106.3091)}} \right]^{-1} \left(e^{\alpha} L_i^{\beta} \right)$$

where L_i is the shell height (in mm) of the ith scallop, and α and β are coefficients of the region-specific length-meat weight regression equation. The term in brackets represents the adjustment for the selectivity of the lined survey dredge, while the term in parentheses converts shell height to meat weight (in grams). Only scallops with shell heights > 40 mm were included in this calculation.

The remaining calculations were similar to those used for ocean quahogs and Atlantic surfclams. Parameters used to calculate d_{ry} for sea scallops are given in Table 9.2.

Example Results

Figure 9.1 shows values for biomass density estimates for the megabenthos - filterers species, sorted by EMAX region.

Production/Growth/Reproduction

No published data were available for any of the three target species. Production values for this node were therefore based on the use of a P:B ratio of 0.8. This value is well within the published range for bivalves (0.28 to 2.91; based on compilation of preexisting data by Dame 1996), and is below the median value, reflecting the slow growth rate of the dominant ocean quahog. No published data was available for any of the three target species.

Consumption

Here again, no published consumption data were available for the target species. Values were based on the use of a C:B ratio of 10. This value is well within values calculated from the compilation of Dame (1.9 to 54.3; 1996), and approaches the value for the American oyster (9.48; Dame 1976).

Respiration

We have chosen to estimate respiration values for the megabenthic nodes from other composite parameters for the same groups:

(EQ. 9.3) $$R = C \times E_A \times 0.65,$$

where R is respiration, C is consumption, E_A is assimilation efficiency, and 0.65 represents the fraction of assimilated energy that is typically respired by ectotherms (Parry 1983). Values for assimilation efficiencies for this purpose were derived from Valiela (1995).

Example Results

Table 9.6 shows values for biomass density, production, consumption, and respiration for megabenthos - filterers in each of the four ecoregions.

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Table 9.1. Shell length-to-meat weight conversion coefficients for ocean quahogs (NEFSC 2004) and Atlantic surfclams (NEFSC 2003). $W = e^{\alpha} L^{\beta}$, where L is in mm and W is in g. SVA-NC = southern Virginia and North Carolina; DMV = Delmarva Peninsula; N/SNJ = northern/southern New Jersey; LI = Long Island; SNE = southern New England; GBK = Georges Bank.

Survey region	Ocean Quahog		Atlantic Surfclam	
	α	β	α	β
SVA-NC	-9.04231	2.787987	-7.0583	2.3033
DMV	-9.04231	2.787987	-9.48913	2.860176
NNJ	-9.84718	2.94954	-9.3121	2.863716
SNJ	-9.84718	2.94954	-9.3121	2.863716
LI	-9.23365	2.822474	-7.9837	2.5802
SNE	-9.12428	2.774989	-7.9837	2.5802
GBK	-8.96907	2.767282	-8.27443	2.654215

Table 9.2. Values of various factors used to convert mean catch per tow to biomass density for ocean quahogs, Atlantic surfclams, and sea scallops.

Factor	Ocean Quahog	Atlantic Surfclam	Sea Scallop
d_s (nm)	0.15	0.15	1.0
$\overline{d}$ (nm)	0.24	0.24	1.0
a_s (nm^2)	0.0008225·0.15	0.0008225·0.15	0.001317·1.0
ε	0.269 (NEFSC 2004)	0.37 (NEFSC 2003)	1.0

Table 9.3. Correspondence between EMAX regions and clam and scallop survey strata. Area corresponds to EMAX region. Three digit scallop strata on GB were defined by splitting strata 62, 63, 65, and 66.

EMAX Region	Clam Strata	Scallop Strata	Area (km^2)
GB	49-74	49-61, 64, 67-74, 621, 622, 631, 632, 651, 652, 661, 662	43,666
GOM	NA	NA	79,128
SNE	25-48, 90-96	25-48, 90-96	64,060
MAB	01-24, 80-89	01-24, 80-89	59,807

Table 9.4. Clam survey regions and defining strata. SVA-NC = southern Virginia and North Carolina; DMV = Delmarva Peninsula; N/SNJ = northern/southern New Jersey; LI = Long Island; SNE = southern New England; GBK = Georges Bank.

Clam Survey Region	Ocean Quahog	Atlantic Surfclam
SVA-NC	5,6	1, 2, 5, 6 80, 81
DMV	9-11, 13-15	9, 10, 13, 14, 82-86
SNJ	17-19, 87	17, 87
NNJ	21-23, 25-27, 88-90	21, 25-28, 88-90
LI	29-31, 33-35, 91-93	29, 30, 33, 34, 91-93
SNE	37-39, 41, 45-47, 94-96	37, 38, 41, 45-47, 94-96
GBK	54-62, 65-74	54, 55, 57, 59, 61, 65, 67-74

Table 9.5. Shell length-to-meat weight conversion coefficients for sea scallops (NEFSC 2001). $W = e^{\alpha} L^{\beta}$, where *L* is in mm and *W* is in g.

Region	Alpha	Beta	Source
GB	-11.6038	3.1221	NEFSC 2001
MAB	-12.2484	3.2641	NEFSC 2001

Table 9.6. Rate values for megabenthos filter feeders.

Subregion	Biomass Density ($g\ m^{-2}$)	Production ($g\ m^{-2}\ yr^{-1}$)	Consumption ($g\ m^{-2}\ yr^{-1}$)	Respiration ($g\ m^{-2}\ yr^{-1}$)
GOM	5.520	4.4160	55.2000	10.7640
GB	17.4466	13.9573	174.4658	34.0208
SNE	15.6055	12.4844	156.0548	30.4307
MAB	15.4301	12.3441	154.3014	30.0888

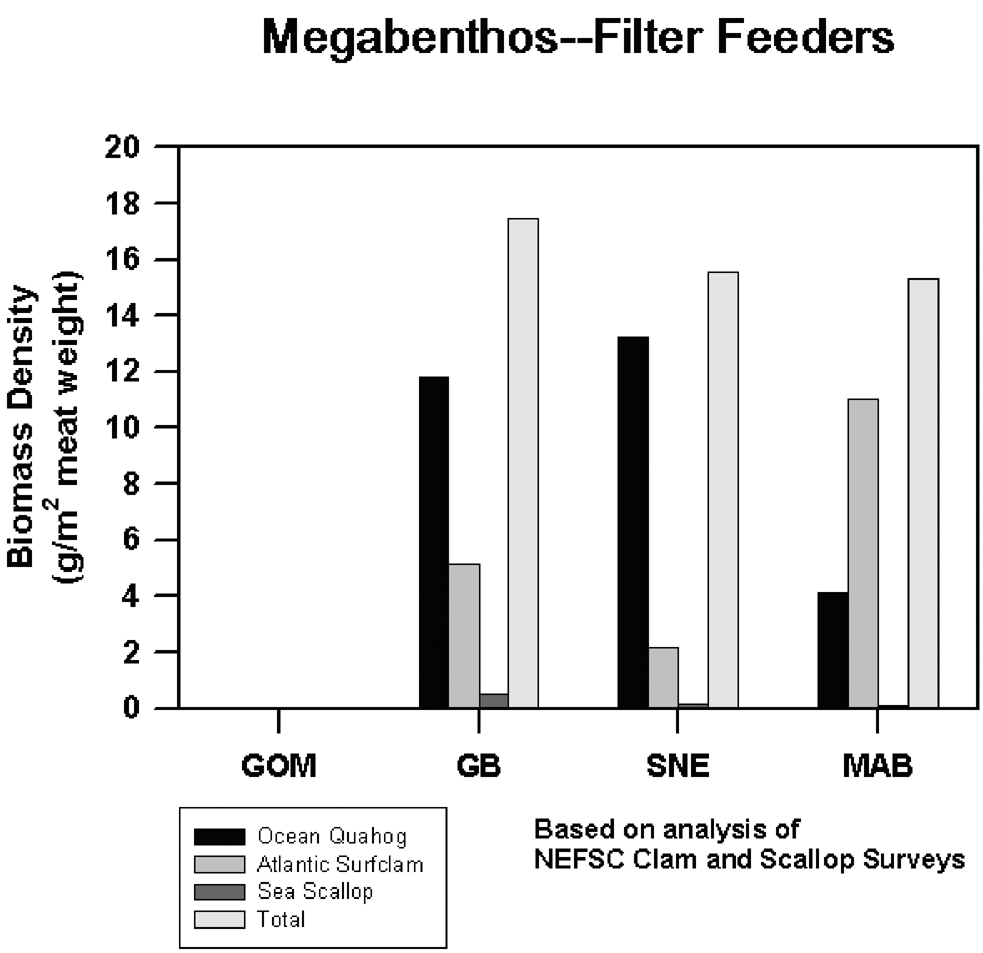

Figure 9.1. Biomass density estimates for the megabenthos - filter feeders species, sorted by EMAX region.