11. Shrimp and Similar Species

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Background

The northern shrimp, *Pandalus borealis*, has a discontinuous distribution throughout the North Atlantic, North Pacific, and Arctic Oceans. In the Gulf of Maine, northern shrimp populations comprise a single stock (Clark and Anthony 1980), which is concentrated in the southwestern region of the Gulf (Haynes and Wigley 1969). *P. borealis* occurs as far south as New Jersey on the continental slope (William 1984). *Dichelopandalus leptocerus* can be found from Newfoundland to North Carolina, from estuaries to the continental slope (Williams 1984). While *D. leptocerus* is not exploited commercially, is an important forage item for a number of fisheries species including monkfish, spiny dogfish, various skate species, red hake, silver hake, and black sea bass (Bowman and Michaels 1984; Bowman *et al.* 2000; Steimle *et al.* 2000). It is the principal non-crangonid shrimp species in the region outside of the Gulf of Maine. *Pasiphaea multidentata*, a circumpolar bathypelagic species largely restricted to the Gulf of Maine in our area, may also play a substantial role as a forage species and consumer of zooplankton and micronekton along with *D. leptocerus* (Cartes 1993, Frank and Widder 1997). Additional caridean and penaeid shrimp species (e.g., *Lebbeus* spp., *Spirontocaris* spp., *Parapenaeus politus*) occur at depths approaching 200 m and beyond in all subregions and in shallower waters of the Gulf of Maine (Williams 1984), but are probably not in sufficient numbers to be important in terms of the system energy budget. The same is likely true of southern penaeids (white, pink, brown, and rock shrimp: *Litopenaeus setiferus, Farfantepenaeus duodorum*, *F. aztecus,* and *Sicyonia brevirostris*, respectively) that may occur in small numbers as far north as southern New England (Williams 1984). Unlike most other decapod shrimps, the very abundant and widespread crangonids (e.g., *Crangon septemspinosa*, *Pontophilus* spp.) are readily captured and assessed by grab sampling, and are therefore included with other such species in the macrobenthos - crustaceans node (Section 8 of this document) rather than here. The species we categorized as shrimp are given in Table 11.1.

Data Sources

Stock assessment for Gulf of Maine northern shrimp reviewed in SARC 36 (SARC 2003) used commercial landings data, Northern Shrimp Technical Committee summer shrimp survey data, and unpublished data from NEFSC Benthic Habitat cruises.

Quantitative Approach for Biomass Estimates

A Collie-Sissenwine analysis was used to estimate biomass of northern red shrimp (*P. borealis*) in the Gulf of Maine. This analysis is based on relating the annual changes in survey abundance for both recruiting shrimp and fully recruited shrimp to the annual catches in order to estimate biomass of northern shrimp in the Gulf of Maine for years 1985 to 2003. The assessment was confirmed using surplus production, a different modeling approach which produced qualitatively similar results. The Collie-Sissenwine model biomass estimates for years 1996-2000 were averaged and then multiplied by 1.5 to account for other species of shrimp. The resulting total shrimp biomass (mt) was divided by the area of Gulf of Maine (km^2) to produce a total shrimp biomass value in units of g m^{-2} (Table 11.2).

Biomass Results

As shrimp are not harvested commercially outside of the Gulf of Maine in the NEUS Ecosystem, this type of analysis could not be used for biomass estimates of shrimp in other subregions (principally *D. leptocerus*). A mean density estimate for *D. leptocerus* was made (0.0171 g m^{-2} or 0.0075 individuals m^{-2}, Guida unpublished) from 2 m beam trawl catches at 38 stations during summer and fall cruises to the outer shelf near Hudson Canyon, along the border between the Mid-Atlantic and Southern New England subregions. While this density is based upon a very limited dataset from a very small portion of the entire region, it is comparable in magnitude to the only published density for this species in the NEUS Ecosystem: 0.0035 individuals m^{-2} (no biomass data provided) calculated from data on a year-round study performed in Penobscot Bay, Gulf of Maine (Stevenson and Pierce 1984). Semiquantitative data from epibenthic sled collections in nearshore waters off New York Harbor also indicate densities in the range of 10^{-3} to 10^{-2} individuals m^{-2} (Guida, unpublished). We have therefore chosen to adopt 0.0171 g m^{-2} as an estimate of shrimp biomass for Georges Bank, Southern New England, and the Mid-Atlantic Bight subregions.

Production/Growth/Reproduction

Production was estimated using a P:B ratio of 1.5 based on the assumption that as large, active invertebrates, P:B should resemble that of squid and megabenthos - other. Production was estimated to be 0.1695 * 1.5 = 0.254214 g m-2 yr-1 in the case of the GOM.

Consumption

Consumption was estimated using a C:B ratio of 13.5 based again on the assumption that shrimp should resemble other large benthic invertebrates. Consumption was estimated to be 0.1695 * 13.5 = 2.2883 g m^{-2} yr^{-1} in the case of the GOM.

Respiration

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

(EQ. 11.1) $$R = C \times E_A \times 0.65,$$

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). Thus, respiration was estimated to be 2.2883 * 0.7 * 0.65 = 1.0412 g m^{-2} yr^{-1} in the case of the GOM (Table 11.3).

Example Results

Values for biomass density, production, consumption, and respiration for shrimp and shirmp-like species in each of the four subregions are summarized in Table 11.3.

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Table 11.1. Species list of shrimp.

Common Name	Scientific Name
Northern red shrimp	*Pandalus borealis*
Other northern shrimps	*P. propinquus, P. montagui*
Bristlebeaked shrimp	*Dichelopandalus leptocerus*
Glass shrimp	*Pasiphaea multidentata*

Table 11.2. Estimates of biomass for shrimp species listed in Table 11.1 in the Gulf of Maine based on model results for northern red shrimp (*P. borealis*).

Fishing Year	Biomass (mt)	
1996	15,516	
1997	11,008	
1998	6,728	
1999	5,791	
2000	5,658	
	8,940	Average for Northern Red Shrimp (mt)
	1.5	Multiplier for Other Shrimp Species
	13,410	Total Shrimp Biomass (mt)
	79127.95	Gulf of Maine Area (km^2)
	0.1695	Biomass ($g\ m^{-2}$)

Table 11.3. Rate values for shrimp.

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	0.1695	0.25425	2.2883	1.0412
GB	0.0171	0.02565	0.2309	0.1050
SNE	0.0171	0.02565	0.2309	0.1050
MAB	0.0171	0.02565	0.2309	0.1050