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# Zooplankton

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## 7. ZOOPLANKTON

### 7.1 Zooplankton

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The West Florida Shelf (WFS) zooplankton community is comprised of oceanic and neritic forms. Hydrographic conditions exist that can transport oceanic and nearshore fauna onto the shelf (Stepien 1980). Upwelling associated with the Loop Current significantly affects plankton production and standing crop on the WFS (Khromov, 1965; Bogdanov *et al*., 1969; Austin and Jones, 1971). These effects are seasonal, with greatest impact in summer. The nearshore plankton communities are also impacted by seasonal variations in runoff, with greatest runoff occurring in summer. Annual variations in temperature also affect plankton abundance to some extent, mainly along the north Gulf coast (Hopkins, 1966). Overall, evidence for distinct seasonal patterns in WFS zooplankton is weak (Vargo and Hopkins, 1990), with peaks of biomass only 2-3 times the minima. Kelly and Dragovitch (1967) found larger macrozooplankton biovolumes differed by a factor of 10 from summer to winter in a study of Tampa Bay and the adjacent Gulf. Fall and spring values were one-half and one-fourth those of summer, respectively. As this estuary undergoes a dramatic seasonal freshwater input cycle (wet in summer, dry in winter), it is reasonable to assume that WFS zooplankton abundances vary less than this amount.

There are few detailed, quantitative published reports on the zooplankton of the WFS. Most previous studies of zooplankton from the eastern Gulf describe estuarine ecosystems (Hopkins, 1966; Kelly and Dragovitch, 1967; McIlwain, 1968; Gillespie, 1971; Hopkins, 1977). The few studies dealing with the shelf fauna were primarily taxonomic and results were not quantitative (King, 1949; Davis, 1950; Grice, 1953; Fleminger, 1965). Arnold (1958) reported plankton volumes for shelf to be 0.171 ml $m^{-3}$ (0.031 mg WW $m^{-3}$ using the conversion regression of Wiebe *et al*., 1975). The most extensive Gulf shelf zooplankton data are those of the Soviet-Cuban fishery investigations (Bogdanov et al., 1969). They found highest plankton productivity in the northern Gulf, mediated by runoff from the Mississippi River and winter destratification. Highest zooplankton biomass occurs in fall and winter in this region. Loop Current-generated upwelling in summer enhances the southWest Florida Shelf production, which results in a biomass peak during this season. Annual ranges of biovolumes for the northern Florida shelf are 0.3-1 ml $m^{-3}$ (0.06-0.2 mg WW $m^{-3}$), while the southWest Florida Shelf values are 0.3-0.6 ml $m^{-3}$ (~0.06-0.12 mg WW $m^{-3}$). Standing crops within these areas can be locally high (e.g. Middle Grounds; Austin and Jones, 1971).

More recently, Sutton *et al*. (2001) conducted a high-resolution survey of zooplankton abundance across the central WFS using a multisensor towed array. These data were collected during the warm season (September 1998) and will be the focus of this chapter. Sampling was conducted using 163 µm mesh nets, chosen to include the smaller copepod forms that dominate this fauna. Most previous studies used larger meshes, excluding the smaller mesozooplankton. Zooplankton samples were processed at the University of South Florida College of Marine Science using standard subsampling techniques. Biomass was determined by applying length/dry weight regressions to size frequency distributions of the subsamples. Dry weights were then converted to wet weight biomass for this model using the empirical relationships of Wiebe *et al*. (1975). Biomass was estimated as mg $m^{-3}$ and then converted to areal estimates (t WW $km^{-2}$) by integrating depth of water column and distance traveled during each deployment.

The overall zooplankton distributional pattern determined by optical sensors (Optical Plankton Counter, Dual Light Sheet; see Sutton *et al*., 2001) revealed a close correlation between hydrography and zooplankton abundance. Abundance maxima were seen nearshore, associated with a salinity gradient, and along the pycnocline offshore. Increased suspended particulate matter characterized both of these zones. These distribution patterns mirror those found on the northeastern Florida shelf (NEFS). Paffenhöfer (1983) found that the dominant copepods of the NEFS region (*Oncaea, Temora, Eucalanus)* showed a significant positive correlation with the abundance of particulate matter. He also found that on a subtropical vertically stratified shelf multicellular zooplankton is most abundant in cooler upwelled water than warmer surface water (Paffenhöfer,1980). Thus, the patterns seen during our warm season transect are reasonably characteristic of the low latitude shelf regimes of the region.

For this model our data were divided into three groups. Group 1 includes carnivorous zooplankton (mainly chaetognaths). The primary prey of this group is copepods, while this group is preyed on primarily by planktivorous fishes (e.g. clupeids). This group dominates the zooplankton biomass in many areas of the WFS, and so is given separate treatment. Group 2 includes small (< 1.5 mm TL) copepods (Paracalanidae*, Oncaea, Oithona*). This group is primarily herbivorous, but much of its diet intake may consist of detritus, as the distribution of this group's members is highly correlated with suspended particulate matter at hydrographic discontinuities. This group is preyed on largely by larger zooplankton and larval fishes. This group is the numerically dominant component of the WFS zooplankton. Sutton *et al*. (2001) found that the genus *Oncaea* alone contributes 50% of the zooplankton numbers across the WFS and is the dominant grazing component (low specific grazing rates are more than offset by high abundance). Group 3 includes other mesozooplankton (larger copepods, meroplankton, ostracods). These groups are the most herbivorous of the three groups, feeding mostly on phytoplankton (e.g. chain-forming diatoms). This group is also the principal prey of the planktivorous baitfishes of the West Florida Shelf (e.g. clupeids, engraulids, carangids), and is thus given separate treatment. In summary, these groupings represent the biomass dominants (Group 1), the numerical and grazing dominants (Group 2), and the principal diet component of planktivorous fishes (Group 3).

Standing stock values across the WFS as a function of depth zone showed variable contributions by each group (Table 7.1). Chaetognaths alone accounted for three-fourths of zooplankton standing stock in the inshore zone (shore to 20 m isobath), while accounting for ~ 40% offshore (20-100 m). Overall biomass estimates of the two zones were quite similar. It should be noted that these estimates should be considered minimal, as younger life stages of the dominant small copepods are undersampled by traditional net-based methodologies.

Table 7.1. Warm season biomass estimates for WFS zooplankton by depth zone.

| Zooplankton component | Inshore biomass[a] (t WW km$^{-2}$) | Offshore biomass[b] (t WW km$^{-2}$) |
|---|---|---|
| Carnivorous zooplankton | 41.7 | 22.8 |
| Small copepods | 8.2 | 16.8 |
| Other mesozooplankton | 7.1 | 12.8 |
| Total | 57 | 52.4 |

[a]shore to 20 m isobath
[b]20 m to 100 m isobath

Seasonal changes in zooplankton biomass are presently being investigated. As a first order approximation, the values presented in Table 7.1 can be considered the summer peak for the southWest Florida Shelf and the winter peak for the northern Gulf (Bogdanov *et al*., 1969). Minimum values could be estimated as one-third of these values (Vargo and Hopkins, 1990). Annualized values were then calculated for the three WFS zooplankton components based on these parameters (Table 7.2). Offshore vs. inshore biomass estimates (Table 7.1) were prorated by the area of each zone on the WFS to generate the annualized values. The copepod assemblage of the WFS is relatively short-lived due to high temperature, resulting in a high P/B ratio (P=B×no. generations year$^{-1}$). Generation times of two and four weeks were taken as summer and winter values, respectively, for small copepods and other mesozooplankton (Raymont, 1983). Generation times of one and two months were taken as summer and winter values, respectively, for carnivorous zooplankton (Reeve *et al*., 1970). Consumption values (Q) were calculated by applying a 30% gross growth efficiency to the yearly production values. Thus, Q/B = P/B×3.33. Lacking a way to measure ecotrophic efficiency, we assigned a value of >0.90.

Assigning diet composition for various zooplankton groups is problematic, especially in low latitude coastal regimes. The concept of herbivory is rarely applicable. Most "herbivorous" forms are omnivorous, taking phytoplankton, detritus, and microzooplankton in varying amounts. The best understood group is the chaetognaths, who show a marked selectivity for copepods (Reeve *et al*., 1970). The small copepods are known to take phytoplankton and detritus, with the latter component unquantified. A first order approximation would be to assign 50% herbivory and 50% detritivory to this group. Larger mesozooplankton take phytoplankton, other crustacean zooplankton (mainly nauplii and early copepodites), and protozoan microplankton. A first order approximation would be to assign 75% herbivory and 25% carnivory to this group. Knowledge of the feeding of some potentially important zooplankton components (e.g. ostracods) is totally lacking.

Table 7.2. Annualized *Ecopath* parameters for zooplankton of the West Florida Shelf.

| Zooplankton component | Biomass (t km$^{-2}$) | P/B (year$^{-1}$) | Q/B (year$^{-1}$) | EE |
|---|---|---|---|---|

| | | | | |
|---|---|---|---|---|
| Carnivorous zooplankton | 21.6 | 8.7 | 29.0 | > 0.90 |
| Small copepods | 8.3 | 17.3 | 57.7 | > 0.90 |
| Other Mesozooplankton | 6.7 | 17.3 | 57.7 | > 0.90 |
| Total | 36.5 | 13 | 43.3 | > 0.90 |

**Literature Cited (Zooplankton)**


Arnold, E.L. 1958. Gulf of Mexico plankton investigations, 1951-53. Spec. Sci. Rep., U.S. Fish Wildl. Ser. Fisheries No. 269.

Austin, H.M. and J.I. Jones. 1971. Seasonal variation in bulk plankton on the Florida middle ground, and its relation to water masses on the West Florida Shelf. Fla. Sci. 37: 16-32.

Bogdanov, D.V., V.A. Sokolov, and N.S. Khromov. 1969. Regions of high biological and commercial productivity in the Gulf of Mexico and Caribbean Sea. Oceanology 8: 371-381.

Davis, C.C. 1950. Observations on plankton taken in marine waters off Florida in 1947 and 1948. Quart. J. Fla. Acad. Sci. 12: 67-103.

Fleminger, A. 1956. Taxonomic and distributional studies on the epiplanktonic calanoid copepods (Crustacea) of the Gulf of Mexico. Ph.D. dissertation, Harvard University Library, Cambridge, MA.

Gillespie, M.C. 1971. Analysis and treatment of zooplankton of estuarine waters of Louisiana. In: Cooperative Gulf of Mexico Estuarine Inventory and Study, Louisiana. Louisiana Wildlife and Fisheries Commission.

Grice, G.D. 1953. A qualitative and quantitative seasonal study of the Copepoda and Cladocera of Alligator Harbor. MS Thesis. Florida State University.

Hopkins, T.L. 1966. Plankton of the St. Andrews Bay system of Florida. Publ. Inst. Mar. Sci. Univ. Tex. 11: 12-64.

Hopkins, T.L. 1977. Zooplankton distribution in surface waters of Tampa Bay, Florida. Bull. Mar. Sci. 27: 467-478.

Kelly, J.A. and A. Dragovitch. 1967. Occurrence of macrozooplankton in Tampa Bay, Florida, and the adjacent Gulf of Mexico. Fish. Bull., US 66: 209-221.

Khromov, N.S. 1965. Distribution of plankton in the Gulf of Mexico and some aspects of its seasonal dynamics. In: Soviet-Cuban Fishery Research, A.S. Bogdanov, editor, p. 36-56 (IPST Translation). U.S. Document TT 69-59016.

King, J.E. 1949. A preliminary report on the plankton of the west coast of Florida. Quart. J. Fla. Acad. Sci. 12: 109-137.

McIlwain, T.D. 1968. Seasonal occurrence of the pelagic Copepoda in Mississippi Sound. Gulf Res. Rep. 2: 257-270.

Paffenhöfer, G.-A. 1980. Zooplankton distribution as related to summer hydrographic conditions in Onslow Bay, North Carolina. Bull. Mar. Sci. 30: 819-832.

Paffenhöfer, G.-A. 1983. Vertical zooplankton distribution on the northeastern Florida shelf and its relation to temperature and food abundance. J. Plankton Res. 5: 15-33.

Raymont, J.E.G. 1983. Plankton and Productivity in the Oceans. Vol. 2. Zooplankton. Pergamon Press.

Reeve, M.R., J.E.G. Raymont, and J.K.B. Raymont. 1970. Seasonal biochemical composition and energy sources of *Sagitta hispida*. Mar. Biol. 6: 357-364.

Stepien, J.C. 1980. The occurrence of chaetognaths, pteropods and euphausiids in relation to deep flow reversals in the Straits of Florida. Deep-Sea Res. 27: 987-1011.

Sutton, T.T., T.L. Hopkins, A.W. Remsen, and S.E. Burghart. 2001. Multisensor sampling of pelagic ecosystem variables in a coastal environment to estimate zooplankton grazing impact. Cont. Shelf Res. 21: 69-87.

Turner, J.T. and S.B. Collard. 1980. Winter distribution of pontellid copepods in the neuston of the eastern Gulf of Mexico continental shelf.

Vargo, G.A. and T.L. Hopkins. 1990. Plankton. In: Synthesis of available biological, geological, chemical, socioeconomic, and cultural resource information for the South Florida area (N.W. Phillips and K.S. Larson, eds.). OCS Study, MMS 90-0019. Pp. 195-230.

Wiebe, P.H., S. Boyd, and J.L. Cox. 1975. Relationships between zooplankton displacement volume, wet weight, dry weight, and carbon. Fish. Bull. US 73: 777-786.