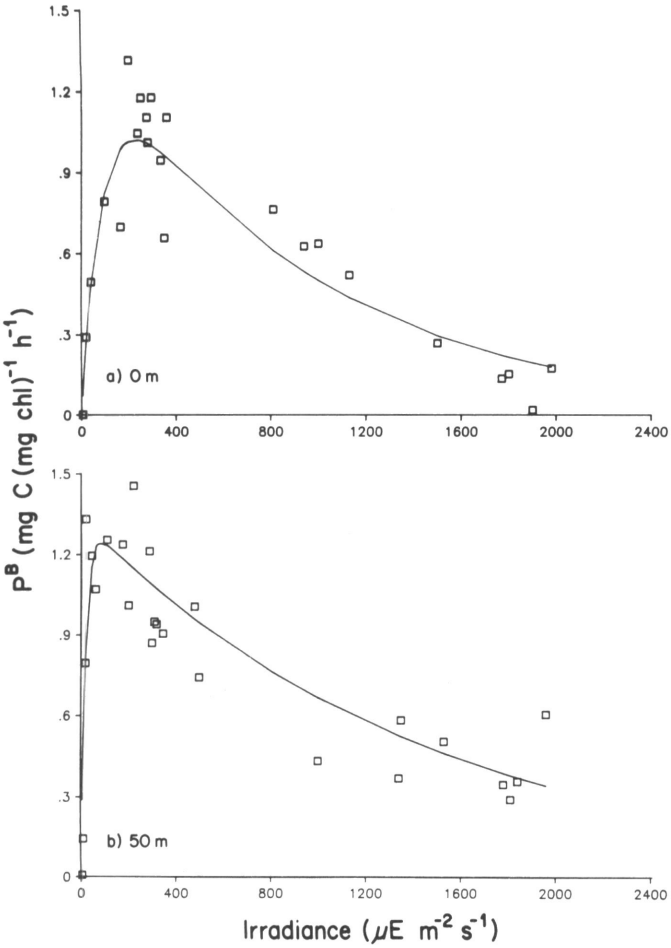

Figure 2. Photosynthesis as a function of irradiance at 0 and 50 meters at station 112 (total depth 150 meters). (Irradiance is measured in microeinsteins per square meter per second. P^B is measured in milligrams of carbon per milligram of chlorophyll *a* per hour.)

present in both surface and in 50-meter populations and was initiated at approximately 300 microeinsteins per square meter per second, with β values averaging 0.001 milligrams of carbon per milligram of chlorophyll *a* per hour per microeinstein per square meter per second (±0.0001).

The large values for photosynthetic efficiencies and the low I_k values indicate that the phytoplankton populations were adapted to low-light conditions (Prezelin 1981). Furthermore, these values were similar to those of ice-algal populations, which grow in low-light conditions (Cota 1985). Absence of vertical variation among photosynthetic parameters within the water column suggests that the time scale of photoadaptation of the phytoplankton populations was less than the time scale of vertical mixing within the water column.

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Lipid biochemistry of antarctic zooplankton: Overwintering strategies and trophic relationships

W. Hagen* *and* E.S. Van Vleet

University of South Florida
Department of Marine Science
St. Petersburg, Florida 33701

Lipids are the major energy store for many marine animals in polar regions, classic examples being the whales, seals, and penguins. Previous biochemical studies on polar plankton organisms have focused on lipids to elucidate the significance of these compounds in relation to the marked seasonality of the polar light and ice regime. Due to the absence of light, phytoplankton is absent during the wintertime, and one major question concerning the functioning of the marine antarctic ecosystem is how the zooplankton, especially the herbivorous species (krill, copepods, etc.), survive during this extended period of food scarcity. There are a number of hypotheses suggesting different overwintering strategies, one of which is the use of high-energy compounds such as lipids during starvation periods.

Previous investigations of the lipid biochemistry of antarctic plankton communities have been carried out for the first time by Reinhardt and Van Vleet (1986a, 1986b) and Hagen (1988) on spring and summer samples from the Antarctic Peninsula and the southern Weddell Sea. Results show high accumulation of lipid stores in many plankton organisms, particularly in crustaceans and fish; however, due to severe ice and weather conditions, very few lipid data are available from plankton

* Also affiliated with *Institut für Polarökologie, Kiel University, Kiel, Federal Republic of Germany.*

organisms collected during the antarctic winter (Littlepage 1964). Thus, the presumably seasonal patterns of lipid accumulation and storage still lack adequate data support.

In 1986, the Alfred-Wegener-Institute for Polar and Marine Research in Bremerhaven, Federal Republic of Germany, planned an antarctic winter expedition with PRV *Polarstern* which offered the unique opportunity to collect winter samples of plankton and fish species. Thus, a cooperative American-German project was started which was supported by the National Science Foundation (grant DPP 86-14029) and the German Polar Research Institutes in Bremerhaven and Kiel, Federal Republic of Germany. For lipid analyses, about 200 samples were collected by N. Mumm (of Kiel) on the first leg (6 May to 27 June 1986, Antarctic Peninsula) and on the second leg (27 June to 26 September 1986, Weddell Sea, maximum 70°S) and about 1,200 samples by E. Mizdalski and W. Hagen on the third leg (28 September to 15 December 1986, Weddell Sea, maximum 77°S). During this leg, some starvation experiments were also carried out. With about 50 zooplankton and fish species, these samples comprise the major biomass species in antarctic plankton (table). All specimens were identified to species level, staged, measured, and stored at −80°C. The samples were shipped to Kiel, Federal Republic of Germany, and then to St. Petersburg, Florida, where the lipid analyses are now being carried out at the Department of Marine Science, University of South Florida.

Main objectives of the study are to compare summer and winter lipid data (total lipid content, lipid class composition, fatty acid composition of different lipid fractions) to investigate seasonal patterns of lipid accumulation and to investigate the depletion of storage lipids (wax ester, triacylglycerol, phosphatidylcholine) during winter. This depletion may be more pronounced in herbivorous than in carnivorous species. Previous studies also indicate different overwintering strategies in different species, e.g., the importance of storage lipids in gelatinous zooplankton seems to be small. The fatty acid spectra will be analyzed to help elucidate trophic relationships via "biomarker lipids" (Reinhardt and Van Vleet 1986a, 1986b). Seasonal changes in the fatty acid spectra might also indicate a diet change due to the absence of some food organisms during part of the year, e.g., phytoplankton. A higher degree of unsaturation in phospholipids might indicate an adaptation to the extremely low water temperatures (minimum −2°C) since higher unsaturation of membrane lipids is believed to sustain the fluidity and thus the functioning of the biomembranes.

Hence, these lipid data will fill a major gap concerning our knowledge about the importance of these high-energy compounds and their ecological impact in the antarctic plankton. The results are expected to elucidate biochemical adaptations that enable the zooplankton to survive the antarctic winter.

List of species collected during the *Polarstern* winter expedition at the Antarctic Peninsula and in the Weddell Sea. Samples are separated into various developmental stages (e.g., eggs, copepodites, furciliae, postlarvae, juveniles, females, males).

Copepoda
Calanus propinquus
Calanoides acutus
Rhincalanus gigas
Metridia gerlachei
Euchaeta antarctica, sp.
Euchirella rostromagna
Ctenocalanus sp.
Candacia sp.
Haloptilus ocellatus
Haloptilus oxycephalus
Metridia curticauda
Oncaea sp.

Euphausiacea
Euphausia superba
Euphausia crystallorophias
Thysanoessa macrura

Amphipoda
Orchomene sp. (*rossi*)
Orchomenella plebs
Eusirus propeperdentatus
Hyperiella sp. (*macronyx, dilatata*)
Hyperia macrocephala
Hyperoche sp.
Primno macropa, sp.
Vibilia sp. (*propinqua*)
Cyllopus lucasii, sp.
Uristes murrayi
Waldeckia obesa

Isopoda
Natatolana albinota
Natatolana obtusata

Mysidacea
Antarctomysis sp. (*ohlini, maxima*)

Coelenterata
Calycopsis borchgrevinki
Diphyes antarctica
Pyrostephos vanhoeffeni
Ctenophora indet.

Gastropoda
Lamellariidae (Echinospira-larvae)
Limacina helicina
Clione limacina
Clio pyramidata

Cephalopoda
Galiteuthis glacialis

Polychaeta
Vanadis antarctica, sp.
Tomopteris carpenteri, sp.

Chaetognatha
Sagitta gazellae
Sagitta marri
Eukrohnia hamata

Tunicata
Salpa thompsoni

Pisces
Pleuragramma antarcticum
Notolepis coatsi

Phytoplankton
various samples (*in situ*, experiments)

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