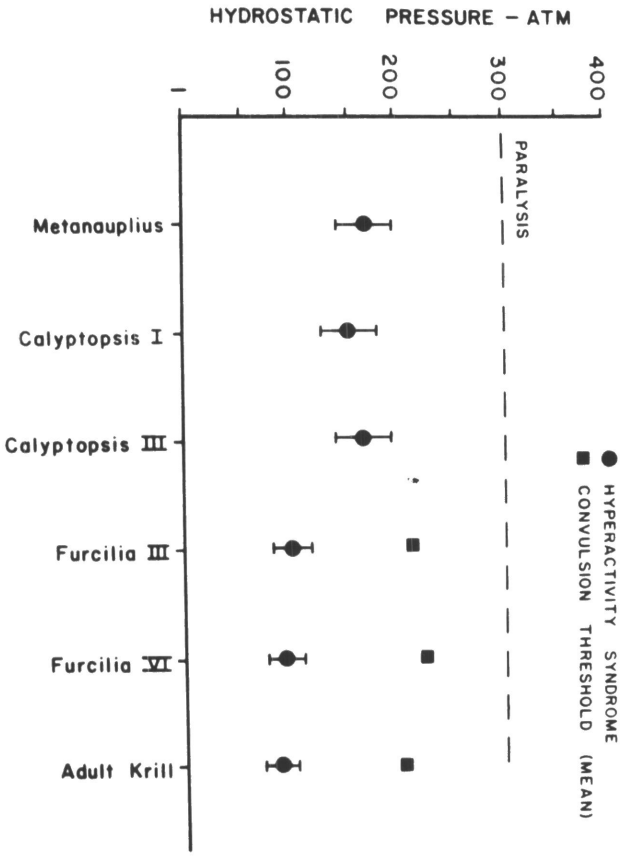

Figure 2. Behavioral pressure responses of adult and larvae of krill showing the lack of convulsive reactions to pressure in early larval stages and higher pressure levels of hyperactivity syndrome in early larval stages at 2 ± 0.5°C.

acclimation is slow and stepwise, involving an increase of 1°C per day. Warm-acclimated krill showed enhanced resting metabolic rate (181.1 microliters/gram/hour at 7.5°C in comparison with 36.4 microliters/gram/hour at 4° C). Prolonged maintenance at 7°C for 30 days appears to stimulate the molting process.

Studies of amphipod crustaceans north and south of the Antarctic Convergence provided new data on their marked differences in thermal sensitivity. Measurement of oxygen consumption and ammonia excretion in the antarctic giant isopod *G. antarcticus* in relation to temperature confirmed the extreme stenothermal adaptation of this endemic crustacean living only in the southern ocean (George 1977, 1979).

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Biological studies of krill, austral summer 1979–80

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Our work this season at Palmer Station was a continuation of previous studies of the biology of krill, *Euphausia superba*. Though the field season was shortened from its usual 4 months (December–March) to 2 months (February–March) because of problems with R/V *Hero*, we did expand our studies of fecundity, embryology, vision, lifespan, and rates of maturation and growth.

During the 1978–79 austral summer, *E. superba* which had spawned in the laboratory were sampled at 2-week intervals. These samples revealed that females did not die after spawning but regressed to a more juvenile appearance, suggesting that the females might spawn 2 years in succession. Consequently, at the end of the season, the remaining animals were left to winter-over in the aquaria so that station personnel could take monthly samples during the winter to determine the time of onset of second maturation. By October 1979, when the last sample was taken, the females did not show any significant increase in ovarian egg size over that observed at the end of March 1979. Similarly, the males exhibited no clear evidence of onset of spermatophore production. It may be tentatively hypothesized that the onset of second maturation is delayed until later in the year, and that the animals spend the winter in reproductive diapause.

Our previous observations on winter-over animals had shown that krill are capable of decreasing in size under poor feeding conditions. These same animals (kept over the 1978 austral winter) nevertheless advanced in maturity, with some mating and spawning the following summer. This, coupled with observations of large variations in body length of animals at the same maturity stage, suggested that rate of maturation might be a more constant factor in the krill life cycle than increase in body length. Thus, examination of

maturation rates should provide more reliable data on the time required for krill to reach reproductive age than the traditional method of studying length-frequency histograms.

Juvenile animals were maintained both in population tanks and in individual containers at approximately 0° and 5°C. Molts were collected daily and analyzed both for external sex characteristic changes and for body length. All animals were fed concentrated phytoplankton collected in the vicinity of Palmer Station, and they maintained the dark green digestive tract color typical of animals freshly caught at sea. As expected, the krill kept at elevated temperature had a significantly shorter intermolt interval than did those kept at 0°C. Analysis of maturation rates at the two temperatures may help clarify whether the various estimates of lifespan which appear in the literature may be attributed to differences in the thermal regime encountered by animals collected in different locations and in different years.

The krill collected for these and other studies were located by observing the sonar recorder aboard the R/V *Hero* and fishing in those areas where aggregations were detected. The mechanism(s) whereby krill maintain their characteristic aggregations is not known, although it appears possible that their bioluminescence might play a role in such behavior. To gain some information as to the likelihood of such a role, the visual pigment of *E. superba* was extracted from eye tissue and studied to determine its wavelength of peak absorption. In general, there is a close correlation between this visual pigment characteristic, the maximum sensitivity of an animal's eye, and a peak behavioral response. The work this season showed that in *E. superba*, the visual pigment is indeed most sensitive to wavelengths similar to those emitted by the krill's photophores. The eye screening pigments were also characterized to permit study of their contribution to wavelength-dependent responses to light which are not directly attributable to visual pigment characteristics.

We are grateful for the work done by the Palmer Station winter-over personnel of 1979, under the leadership of John Konecki, in maintaining and sampling the winter-over krill, and for constructing a dark laboratory for the visual pigment work. We are also indebted to Captain Pieter Lenie for krill-fishing efforts on our behalf.

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Temperature effects on protein metabolism in cold-adapted fishes

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Biochemical reactions in living organisms are highly temperature dependent, with rates declining by a factor of about 2.5 with each 10°C reduction in temperature. Thus, a large difference in metabolic rate can be expected between antarctic fish with body temperature near −2°C (water temperature at McMurdo Sound) and other vertebrates, such as temperate fish in 10°–30°C water or mammals with a regulated body temperature near 37°C. In spite of these low rates, antarctic fish must be able to maintain growth and reproduction and all other essential functions of life.

We are examining the regulation of metabolism in relation to temperature through studies of protein synthesis, the last step in the expression of hereditary information as encoded in the DNA of the species. Our previous results have indicated that, through evolutionary adaptation, antarctic fishes have achieved a two- to threefold increase of synthetic capacity relative to levels expected at their habitat temperature (Haschemeyer, Hudson, Mathews, and Smith 1979; Smith and Haschemeyer 1980). The relative proportions of synthesis of various proteins, including the antifreeze glycoprotein, and some properties of the DNA of these species have also been examined (Haschemeyer and Mathews 1980; Hudson, Cuny, Cortadas, Haschemeyer, and Bernardi 1980).

During the second year of this project, field work was carried out at McMurdo Station from October to December 1979. Our major objective was the experimental determination of temperature effects on the protein synthetic system of antarctic fish at three levels of organization: *in vivo*, in isolated cells, and in cell-free systems *in vitro*. Specimens of *Trematomus hansoni* and *T. bernacchii* were obtained with baited traps in 20–100 meters of water through the sea ice. Tidal cracks near Turtle Rock (77°45'S 166°46'E) and along the coast toward Cape Bird were particularly productive. Protein synthesis in liver *in vivo* was measured by a pulse injection technique in anesthetized fish maintained with circulating seawater at the desired experimental temperature. The rate of incorporation of radioactive amino acids into protein showed a normal increase with temperature from 0°C to 5°C, but fell off rapidly above that temperature. Amino acid accumulation by liver, however, was not affected. Similar effects are obtained in temperate fish, but only at temperatures above 30°C.

In contrast to the results for liver *in vivo* , isolated hepatocytes showed increasing protein synthetic activity up to 20°C, with serious inhibition not occurring until 30°C. Figure 1 shows cells prepared by collagenase perfusion of liver at 5°C and incubated at a concentration of .04 gram/milliliter in a medium containing 25 millimolar imidazole