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Experiences in Integrative and Comparative Biology

SICB members like a good story about an expedition, a field experience, a lab experiment, or another researcher! To spice up our newsletter, I have asked some of the leaders of SICB to relate one or two experiences that might be of interest to the membership. President Sally Woodin and President−elect John Pearse have provided us with some great examples of truly integrative and comparative biology.

Lou Burnett, SICB Secretary

Sally Woodin, SICB President

I am currently on sabbatical having a wonderful time doing research and recovering from being both President of SICB and Chair of my department, not a clever move and life is much improved now that I am merely the former. One project that I am doing in collaboration with David Wethey with support from the Office of Naval Research involves measurement of the rates at which large infauna, the organisms that live in sediments, modify their habitat. Just to put this in perspective, these biogenic rates are major forces in rather important processes such as bacterial growth rates, remineralization rates, porewater movement and exchange, acoustic properties of sediments, recruitment of infauna, predation, etc., thus working on feculence and other organism byproducts has potentially important implications. We have succeeded in using pressure sensors to measure the hydraulic activities of the large infauna.

David Wethey placing pressure sensors

Almost all organism activities within sediments alter porewaters since due to the properties of many sediments, organisms must pump water into the sediment in order to move within it. This changes the pressure in the porewater which we can measure and the form of the pressure wave is uniquely associated with different behaviors so one can essentially spy on the infauna, categorize the frequency of different behaviors etc using pressure sensors both in the field and in the laboratory. As an experimental tool this is an outstanding advance, allowing us to manipulate the habitat and monitor responses without destructive sampling. As an advance in the behavioral analysis of infaunal activities, it has revolutionized my view of their activities, the degree to which individuals interact below the sediment surface, and the importance of those interactions. Some photos of our recent work show that we succeeded in measuring the hydraulic head caused by these infaunal activities, measurements which allow calculation of advective porewater flux.

Field lab in Spain

John Pearse, SICB President−elect

The integrative and comparative underpinnings of my Antarctic research

I suspect that all of us have suffered through the interminable graduate seminars in which a professor selects a series of papers, and each week one student is on the spot, summarizing the paper of the week while a few others criticize. Most participants just try to get through it, rarely participating. I conducted such seminars throughout my teaching career, often thinking back to the first one I experienced myself as a first−year graduate student at Stanford University in 1959.

The professor of that seminar class, Arthur Giese, who turned out to be my major professor and to whom I will be forever indebted, had selected papers that he had used the previous year to write the seminal review on a little−studied topic: reproductive rhythms of marine invertebrates. I recall the sessions as deadly dull; Giese rarely spoke and only a few student participants had anything insightful to say. I hardly spoke at all. On the other hand, I found the topic, and what little was known about it, fascinating. It was global in scope and few attempts had been made to develop unifying principles. At the time, most work on the problem had been done in the North Atlantic, where strong seasonal sea−temperature fluctuations correlated well with seasonal reproductive rhythms. A few experiments had been done on oysters and barnacles demonstrating that change in sea temperature could change the timing of reproduction. Ergo−−− changes in sea temperatures were thought to be all important in regulating the timing of reproduction. Trouble was there were scattered reports that some species in topical, polar, and deep seas, where sea temperatures were unvarying year round, had seasonal reproduction. But the reports were sketchy and generally questionable.

A chance to work at McMurdo Station in the Antarctic offered me the opportunity to examine in detail reproduction of selected polar species. I grabbed it, and spent 14 months there, 1960−1962. Not only did I document reproductive seasonality in several species, but I also followed changes in biochemical composition to show a variety of integrated seasonal changes. These findings led to my working on comparable tropical species, particularly in the Gulf of Suez where marked seasonal changes in sea temperatures occur, and finally in California, where I could demonstrate with some of my students that photoperiodism is a major factor regulating seasonality of reproduction in sea stars, sea urchins, shrimps, and worms. That work led to a return to the Antarctic to show, not unexpectedly, that photoperiodism is important there as well.

John Pearse running a Warburg apparatus at McMurdo Station, Antarctica in 1961.

The big surprise in 1961 came when I found that the focal species of my research, the sea star *Odontaster validus*, produced larvae that looked for all the world like pelagic planktotrophs. One of the few established ideas at the time was that conditions in polar seas were much too severe for pelagic larvae of any kind to survive, and phytoplankton was present for too short a period during the summer to support feeding larvae. Moreover, I found that *O. validus* spawns in mid−winter when no phytoplankton is produced at all. I sat on my finding for nearly 8 years before publishing it, and when I did I suggested that the larvae must be benthic. It wasn't until the mid−1980s that I had a student (Sid Bosch) who was interested in spending a year at McMurdo to re−examine these larvae. His work with me established the fact that the proportion of species with pelagic larvae in the Antarctic was similar to that in other parts of the world. There is no latitudinal gradient in the proportion of species with non−pelagic larvae as had long been believed. Later collaboration with Sid, Richard Rivkin, Donal Manahan, and our students, established that the metabolic rate of polar larvae is extremely low, so that very little food is needed to support them. Moreover, the larvae have the ability to feed on bacteria, which are much more evenly distributed throughout the year, as well as (probably) dissolved organics. Nutrition of larvae also is not a problem as previously supposed.

But if that is the case, why are several large clades of species without pelagic larvae present in Antarctic seas? These clades fueled earlier ideas that severe polar conditions selected against pelagic larvae. Comparing the abundance of brooding species in different parts of Antarctic seas, Sid Bosch and I saw that they occur mainly in Subantarctic waters, particularly in the Scotia arc area between South America and the Antarctic Peninsula. This clue alerted us to the possibility that speciation of brooders might be occurring there, where the powerful Antarctic Circumpolar Current has been flowing in one direction for some 30 million years. That is a lot of time for individuals of brooding species to be wafted to new locations, founding new species nearly upon establishment. This idea, published in 1994, has now been strongly supported by the work of my last student, Susanne Lockhart (co−sponsored with Rich Mooi), who has shown with molecular analyses that the speciose, Antarctic clade of brooding cidaroid sea urchins has been accumulating species for 30 to 40 million years (long before the area cooled), while sister brooding clades north of the Antarctic Circumpolar Current, in South America and New Zealand, have not.

John Pearse with friends at McMurdo Sound, Antarctica in 1990.

These studies have utilized a wide range of approaches and techniques, both in the field and lab, that are both integrative and comparative. Indeed, they could not have been done any other way. And they all began for me with what at the time appeared to be a deadly dull graduate seminar to somehow get through. I'm still in it.

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