ADVANCED COURSE ON MARINE ZOOPLANKTON ECOLOGY PONTAL DO SUL, BRASIL: A SUMMARY

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During the entire month of July 1995 an international "Advanced Course on Marine Zooplankton Ecology" was held at the Centro de Estudos do Mar (CEM) of the Universidade Federal do Paraná in Pontal do Sul, Paraná, Brasil. This course included 13 students (listed in Table 1) from five Latin American countries (Argentina, Brasil, Chile, Ecuador and Mexico), and instructors from Brasil (Björnberg, Brandini and Lopes), Germany (Bathmann) and the United States (Turner) (Photo 1). Because this experience was scientifically as well as culturally enlightening, for both students and instructors, we briefly summarize significant aspects of this effort, in the hope that our course might serve as a model for similar endeavors which might be attempted elsewhere.

The idea to conduct an advanced international course originated with Brandini, Director of the CEM, as a consequence of his national activities within the IOC framework. Being acquainted of the importance of the Training, Education and Mutual Assistance (TEMA) Program of IOC and the lacking of sufficient knowledge on zooplankton in Latin America, in order to improve participation and better interaction with international programmes, he approached Turner with this idea in 1991, and began serious preparation for this course in 1993. Funding for the course came from a

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Photo 1

Participants (instructors and students) of the ADVANCED COURSE IN MARINE ZOOPLANKTON ECOLOGY, held at Pontal do Sul, Brasil, 1-30 July 1995. From left to right: (standing up behind) Ulrich Bathmann, Frederico Brandini, Nelson Yoneda, Rubens Lopes, Jefferson Turner and Sergio H. Trujillo; (sitting in the front row) Marilene C.G.Lima, Andrea S. Freire, Eneida M.E. Sant'Anna, Liang T. Hua, (sitting behind) Jose G. F. Bersano, Tagea Björnberg, Charles Gorri, Fernando A. Cordeiro, Nora C. F. Araoz, Mayza Pompeu, Gladys del C. A. Guzman, Carlos A. Silva and Tarcisio Cordeiro (photographer).

combination of sources, including the Intergovernmental Oceanographic Commission of UNESCO, and the Brazilian Ministry of Science and Technology through the "Conselho Nacional de Desenvolvimento Científico e Tecnológico" (MCT/CNPq). This funding was primarily for travel and *per diem* expenses for instructors from abroad, and travel expenses for the students. Other support in terms of personnel, supplies and equipment were provided by the CEM, co-ordinated primarily by Lopes.

Pontal do Sul is a tiny seaside resort and fishing village (25°30'S, 48°30'W) that although picturesque, is virtually deserted in winter (July). Thus, most students and instructors ate meals in the cafeteria and stayed in dormitories at the CEM throughout the month of the course. This promoted considerable social interaction and synergy between students, instructors and staff of the CEM that otherwise might not have occurred.

The students represented differing but generally high levels of experience. Students ranged in age from 27 to 43 (average = 34), ten had Master's degrees, and two had doctorates. Another one was currently working on a Master's degree, and five were doctoral students. Ten of students had authored or coauthored 3-20 publications each (average = 8.7). These students were selected by Brandini and Lopes from a pool of nearly 30 applicants because of prior experience, and in some cases present employment as research scientists or university instructors in their respective countries, and know-

ledgable written statements about what they hoped to gain from participating in the course. Because the course was to be conducted in English, students were asked to submit their applications in that language, the quality of which was an additional criterion for selection.

Although most of the students had performed previous research on zooplankton, it was mainly taxonomic and community analysis work on preserved samples. Subjects of prior experience or current interest included tintinnids, copepods, euphausiids, chaetognaths, hyperiid amphipods, brachyuran larvae, gastropod veligers, and interactions of zooplankton and ichthyoplankton.

Few of the students had ever worked with live zooplankton but it was clear from the start that all of them wanted to learn how to do so. Thus, the instructors designed numerous laboratory exercises for the practical portion of the course that featured experimental studies with living zooplankters (Photo 2). Examples of such studies included grazing and predation experiments, measurements of copepod egg production rates and egg hatching success, and zooplankton respiration.

Photo 2
Students in the lab preparing experiments.

Many of the grazing studies required measuring changes in abundance of phytoplankton, but almost none of the students were experienced with phytoplankton techniques. Thus, the instructors launched the practical portion of this course on *zooplankton* ecology by teaching the students about *phytoplankton!* Turner gave lectures on phytoplankton taxonomy and dynamics and zooplankton feeding ecology, and the students learned how to measure phytoplankton pigments with a fluorometer,

and to count and identify phytoplankton cells with an inverted microscope. By the end of the first two weeks of the course, the students had learned sampling techniques for collecting live zooplankton from nearby Bay of Paranaguá, and had performed copepod feeding experiments, with ingestion and clearance rates being determined in terms of both phytoplankton cells and chlorophyll. They then performed a gut fluorescence experiment, again using copepods, and algal cultures maintained at the CEM.

Since the course included both lecture ("theoretical") and laboratory ("practical") portions, the usual working format for the course was lectures each morning followed by laboratory exercises in the afternoon (Photo 3). However, this format was frequently adjusted due to weather or tidal aspects of sampling, or complications with laboratory exercises. An example of this was when initial phytoplankton levels had to be determined in the morning prior to initiating afternoon feeding experiments with animals that were being collected the same morning. In another case, a planned laboratory exercise had to be postponed for several days (with additional lectures substituted) because copepodites which dominated plankton catches had not yet moulted into adult females, precluding a scheduled egg production experiment.

Photo 3
Students in the lab analysing zooplankton from the Bay of Paranaguá.

There were also frequent evening lectures after dinner, which usually were "seminar" presentations of recent research activities by instructors or students. A highlight of the course was that almost all of the students gave lectures (all but one in English) on their research, and on activities at their home institutions. In most cases these were presentations of Master's or Doctoral thesis research, with previews of results from ongoing studies.

Because not all of the instructors were able to participate in the entire course, scheduling of lecture or laboratory subjects was designed to capitalize on areas of instructors' expertise during periods when they were available. For instance, since Björnberg was able to participate in only the first week of the course, she immediately held several laboratory sessions teaching the students how to identify nauplii and later stages of local copepods (Photo 4). Björnberg also gave lectures on biogeography of copepods from waters of Brasil and the southwestern Atlantic, as well as on the taxonomy and ecology of copepod nauplii. Since Bathmann was able to participate in

Photo 4

Tagea Björnberg and Jefferson Turner showing copepod larvae and the general zooplankton composition in the Bay of Paranaguá using video facilities.

only the first half of the course, activities with which he was most experienced (gut fluorescence, fluorometer calibration and chlorophyll measurement) were done at this time (Photo 5). Further, Bathmann presented several lectures on international interdisciplinary programs with which he was involved, such as the Southern Ocean JGOFS and GLOBEC studies. He also gave lectures on the theory and calculations of phytoplankton pigment determination, gut fluorescence measurements, and an evening lecture on pollution in the Baltic Sea (Photo 6).

During the third week of the course, Turner gave numerous lectures such as a taxonomic and ecological overview of the organisms comprising the zooplankton, gelatinous zooplankton, zooplankton-larval fish interactions, bacterioplankton and the microbial loop. By this time, students were familiar enough with live-sorting and phytoplankton counting techniques so that most were performing their own feeding or

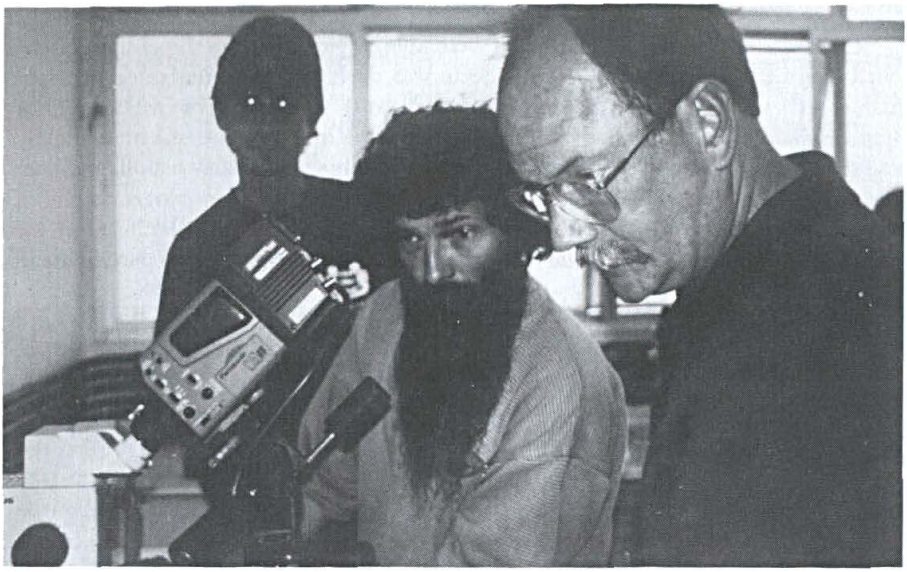

Photo 5
Jefferson Turner, Ulrich Bathmann and Rubens Lopes setting up the video equipment for the analyses of alive zooplankton.

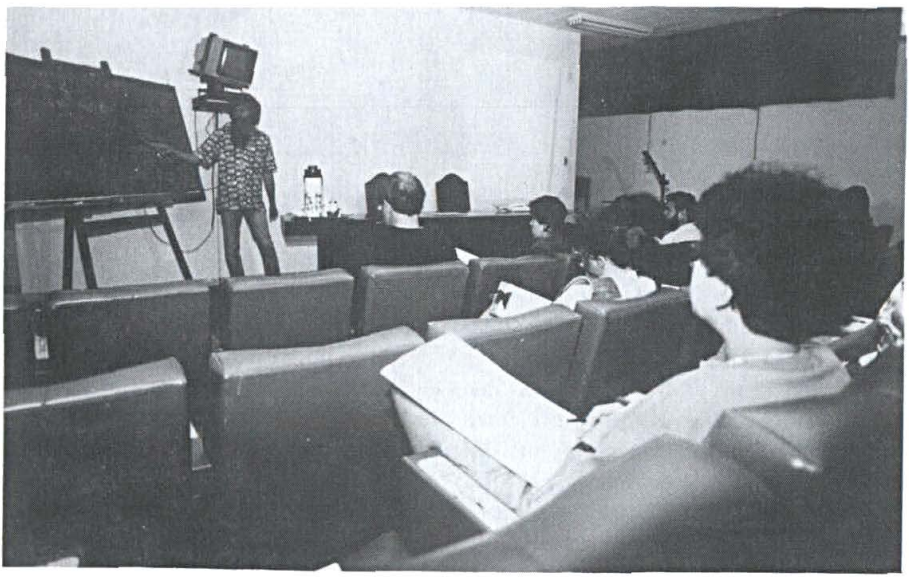

Photo 6
Theoretical class by Ulrich Bathmann.

egg production experiments with organisms of particular interest to them. Examples of such studies included grazing of tintinnids on cultured microflagellates, predation on copepods by crab megalopa, and feeding by several species of copepods, gastropod veligers, or barnacle larvae on various combinations of phytoplankton, tintinnids, and copepod nauplii. Students were advised and assisted by Turner and Lopes, but in most cases, students worked independently or in small groups.

In terms of experimental organisms, we became adept at using "whatever the plankton nets provided". For instance, during the third week when we hoped to obtain adult female *Acartia lilljeborgi* for an egg production and hatching experiment, the catch in 300 μm-mesh nets was dominated by males of *Corycaeus giesbrechti*, and the catch in coincident 50 μm-mesh tows was dominated by tintinnids and copepod nauplii. Thus, we quickly switched to performing an experiment to examine selective predation by *Corycaeus* on tintinnids versus nauplii (Fig.1). Similarly, when catches were dominated by barnacle nauplii, *Labidocera fluviatilis* copepodites, and tintinnids, students examined comparative predation on tintinnids by copepodites and barnacle larvae (Fig. 2). Sometimes, when net collections contained predators such as chaetognaths or ctenophores, that were not in sufficient numbers for performing feeding experiments, students simply observed and often videotaped feeding interactions discussed in lectures, such as these predators eating copepods. In short, instructors were frequently unsure about exactly what students would be learning on a given day, but were always sure that students would be learning something interesting.

In some cases, important lessons resulted from mistakes during experiments. For instance, during a feeding experiment designed to study selective grazing upon cultures of *Skeletonema costatum* versus *Isochrysis* sp, microscopic counts by the students revealed that during the 24-hour grazing incubation, the *Isochrysis* culture had become contaminated by disproportionate growth of another phytoplankter, similar to *Nannochloris* sp. This was probably introduced from incomplete filtration during preparation of filtered seawater for dilution of the culture to experimental concentrations. The students did not initially know what the contaminant phytoplankter was, but they counted it anyway as "monads". Since these monads had not been detected in the initial *Isochrysis* counts, but a day later were abundant in the control and in experimental containers, this compromised calculations of ingestion and filtration rates in terms of chlorophyll. However, microscopic counts revealed that the more abundant monads were much more extensively grazed than the less-abundant *Isochrysis*, revealing non-selective feeding on the most abundant food item. Another lesson from this experiment was that some filters (GFA) did not as completely remove cells while filtering seawater as did more-expensive glass fiber GFC filters.

During the fourth week of the course, students continued to wrap up individual experiments, mostly on feeding interactions. Also, the entire class performed an egg production and egg hatching experiment in which *Temora turbinata* females were acclimated for a day to four different diets: cultures of *Skeletonema, Isochrysis* and monads, natural seawater (all three at the same chlorophyll concentration) and filtered

sea water. For some unexplained reason, few eggs were produced. Students also performed an experiment comparing respiration rates of *Temora turbinata* and *Corycaeus giesbrechti*, in which oxygen concentrations were measured by Winkler titrations. Students also had a demonstration of use of epifluorescence microscopy for counting bacterioplankton, and heterotrophic versus autotrophic protists.

Turner continued to lecture most days during the last week. He gave an overview of red tides and other harmful algal blooms, and their relation to zooplankton and higher trophic levels. There was also a lecture/discussion on methods of measuring zooplankton biomass, and a final lecture on how many of the laboratory methods learned in the course (consumption, reproduction, and respiration rates) could be coupled with abundance and biomass of zooplankton populations to estimate zooplankton production. Instructors were pleased to hear many students express the intention to couple such laboratory techniques with their ongoing programs describing community structure and zooplankton abundance and biomass.

The course was conducted in a very democratic manner. Students were encouraged to contribute suggestions, comments and criticisms regarding all aspects of the course, including topics for lectures, experimental design, and scheduling. Most decisions were reached by consensus. When a student had an idea for an experiment that he or she wanted to conduct, instructors tried within limits of logistics to facilitate the experiment. When comments from students suggested that procedural adjustments would likely result in improvements, these were implemented.

As to be expected when persons from seven different countries interact continuously in an isolated environment, we learned much about each other. Although the course was conducted in English, some participants were less comfortable with this language than others. Thus, we tried to learn to listen carefully and be patient with each other when conversing. One instructor had to continuously remind himself to speak more slowly than his usual auctioneer's pace when lecturing. Interestingly, however, it became clear that even though the native languages of all the students (Spanish or Portuguese) are in many ways similar, on occasion, if a native-Spanish-speaking student spoke too quickly in Spanish to a native-Portuguese-speaking student (or vice versa), the listener would request that the speaker slow down. This also was sometimes a problem when ordering in Spanish in a local restaurant.

Winter in southern Brasil is a time of traditional festivals. Thus, we visited "caipira" festivals (festivals similar to those of traditional Brazilian agricultural people) in Pontal and neighboring towns, and even held our own at the CEM for course participants and other CEM personnel (complete with a bonfire, traditional music and Brazilians teaching local folk dancing to visitors). Other social activities included playing soccer on the beach after work, sightseeing along beaches, and attending an outdoor concert by a Brazilian rock group in a nearby town. In short, although it seemed that we were frequently working day and night, enough non-work activities were added to the program so that the work load did not become oppressive.

This course was a broadening experience for students and instructors. What made it work well was that everyone (instructors, students, and CEM staff) were trying very hard to make it successful. If similar courses are envisioned for other locations we have several recommendations based on our experience with this one.

An isolated environment with few distractions is conducive to people working hard and continuously (because there is little else to do) and this makes time pass quickly. This is important when students and instructors are away from their homes and families for as long as a month.

It is essential to have neccessary literature, equipment and supply resources available at the outset for conducting the course. In the worst example of this not occurring, a package of copies of articles to be read by the students, that were sent by Turner three months prior to the course, arrived the day before it ended.

Improvisation and willingness to change plans on short notice are essential in such a course. Nets often do not provide desired organisms, weather and logistics complicate envisioned activities, and instructors and students must learn to be opportunistic in terms of doing worthwhile activities with whatever organisms and resources are available.

When numerous people are working on the same exercise, and this is their first experience with many of the techniques, experiments frequently do not work as well as planned. Instructors and students must keep in mind that what is most important is the experience of going through the exercise, and learning from mistakes, not neccessarily obtaining the desired results the first time.

The Director of an institution holding such a course should commit all staff of the institution, including those who are not directly involved in the course, to give the course first priority for the entire institution, clarifying that assistance and co-operation by all institution staff is expected. The outstanding cooperation by the entire CEM staff was a major factor in the success of our course.

People cannot work all the time, so intertwining of planned work and social activities is essential. Also, people feel better about the course if they have time to unwind (either in groups or alone), colleagues are friendly and patient, and the food is good. Most importantly, since students and their institutions have made major commitments in terms of time and money to participate in such a course, students must feel that they are getting what they came for. The best way to facilitate this is for students to feel that their opinions on conduct of the course are welcome and important. Thus, the most important aspect of a successful international course is that it be conducted in a democratic manner with constant communication between, and mutual respect for, all participants.

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Table 1 - List of student participants in the Advanced Course on Marine Zooplankton Ecology/July 1995, Pontal do Sul, Brazil.

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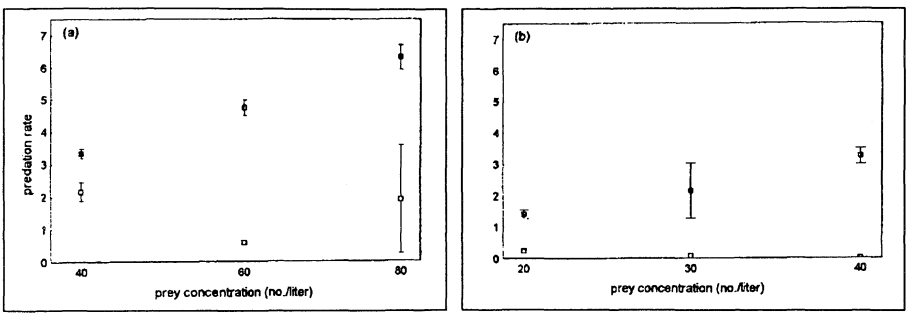

Fig.1

Average predation rates of *Corycaeus giesbrechti* (prey consumed/predator/day) feeding on copepod nauplii (open squares) and tintinnids (filled squares). Prey concentrations are referred to individual prey types; bars refer to standard deviations. Results showed that *Corycaeus* consumed preferentially tintinnids, in both isolated (a) and combined (b) treatments. Some nauplii were preyed by *Corycaeus* when offered as the only food source, but nearly none when offered together with tintinnids.

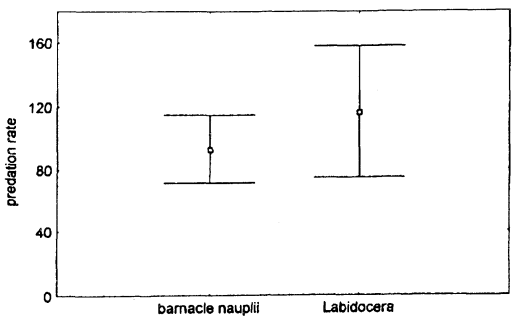

Fig.2

Average predation rates of *Labidocera fluviatilis* and barnacle nauplii feeding on tintinnids (mainly *Tintinnopsis* spp). Values are given in terms of prey consumed/predator/day. Predation rates were high but not statistically different (paired t-test, $p < 0.05$).
Bars refer to standard deviations.