Appendix VII

CICOR Student Support / Graduate Student Research Assistants

Graduate Student Research Assistants
CICOR provides the framework at WHOI for coordinating NOAA-funded research, for building ties between WHOI investigators and colleagues at NOAA laboratories, and for developing cooperative NOAA-funded research at academic institutions in the northeastern United States. Graduate Student Researchers will be associated with the research activities related to CICOR themes and funded through CICOR. Program development costs support the WHOI-NOAA Cooperative Institute for Climate and Ocean Research educational program.

CICOR is currently supporting two Joint Program Students for the 2004-2005 school year:

Rob Jennings is continuing his graduate studies in the Biology Department and J. Thomas Ferrar, is in his 4th year in the Physical Oceanography Department.
J. Steven Fries was the Joint Program Student formerly supported by CICOR.

Rob Jennings, Graduate Student

Summary of Accomplishments (Written in Summer 2004)

I have spent most of the past year investigating population genetic variation of the marine polychaete worm Clymenella torquata (a bamboo worm of the family Maldanidae). During the summer of 2002, I collected ~30 worms from each of several sites around Cape Cod (Buzzards Bay, Hyannisport, Stage Harbor, Pleasant Bay, and Barnstable Harbor), as well as from Pembroke, ME and Belmar, NJ. I sampled these sites again in the summer of 2003, and added samples from Chance Harbor, New Brunswick (Bay of Fundy) and Gloucester Point, VA. These worms comprise the study organisms for the first chapter of my dissertation, which consists of a gene flow analysis to determine 1) if the Cape Cod peninsula is an effective biogeographic or genetic barrier between the Gulf of Maine region and the middle Atlantic coast of the U.S., as has often been hypothesized, 2) whether the Cape Cod Canal allows transfer around this putative barrier, and 3) what the patterns of gene flow are in Cape populations of C. torquata. I have sequenced the mitochondrial gene ATP6 (involved in the synthesis of ATP) for approximately 3/4 of the worms collected I am investigating amplified fragment length polymorphism (AFLP) analyses for use as nuclear markers. The data obtained thus far indicate little to no contemporary gene flow (that is, each population bears a distinct genetic signature; see Figure One). There are two main genetic signatures (haplotypes) found in all locations, and rarer closely-related haplotypes specific to each location. The presence of only one genetic signature (haplotype) in New Brunswick and only 3 haplotypes in Maine (2 of them rare) indicate that C. torquata's has recently re-colonized these sites, in contrast to the older populations on the Cape and in New Jersey, where there is considerably more haplotype diversity. This pattern of lower genetic diversity in northern sites is typical of glacially influenced dynamics, where ice sheet advances destroy northern populations, which then slowly return and rebuild genetic diversity during interglacial periods.

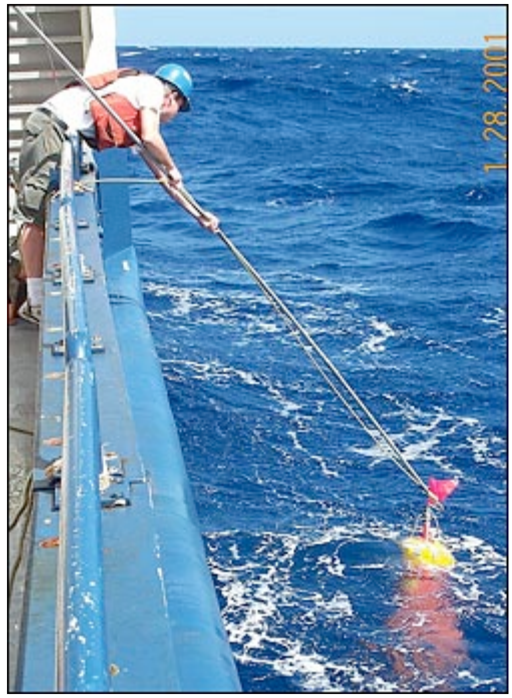
In addition to the adult collections described above, I collected juvenile (<3cm) worms from Barnstable Harbor for the second objective of my dissertation. These juveniles should provide a better estimate of dispersal (which involves only organism movement between locations, as opposed to gene flow which includes survival to adulthood and reproduction in the new location) because most benthic (soft-bottom) invertebrates experience extreme mortality (upwards of 90% in some cases) in the period just after dispersal and settlement. Population genetic studies traditionally sample adults, whose genetic diversity may already have been culled by this post-settlement mortality, thus underestimating the true amount of dispersal that occurred.

My third objective has been to develop a theoretical framework for the issues and complexities introduced by the second objective. No current population genetic models incorporate two-stage (i.e., juvenile and adult) dynamics, nor do they consider the possible effects of severe post-settlement mortality. The third objective thus seeks to interpret any differences seen between the gene flow estimate of the first objective (based on adults) and the dispersal estimate of the second objective (based on juveniles). To further develop the third objective, I traveled to Berkeley, CA, in May 2003 to visit Montgomery Slatkin. Dr. Slatkin is at the forefront of theoretical population genetics, and I discussed with him in general terms the issues and forces that would be important to such a model, as well as its general form. I am hoping this will lead to a more formal collaboration for this chapter of my dissertation.

In the fall semester of 2002, I was the TA for WHOI's new Invertebrate Biology class. The course was designed as a pilot project; it was taught once a week in seminar style, in hopes that it could eventually be built into the sort of full-scale Invertebrate Biology class that WHOI has offered in the past. Professor Stace Beaulieu and I used my trips around the Cape last summer to collect marine invertebrates for the class. TAing this class was a great opportunity for me to help teach the type of class I had just attended in Friday Harbor. I think the course was a great launching point for what will hopefully become a full-time class; the students enjoyed the class thoroughly but cited lack of adequate class time as a serious drawback.

J. Thomas Farrar, Graduate Student

Ph.D. Candidate, MIT/WHOI Joint Program
S.M., MIT/WHOI Joint Program, 2003
B.S. in Physics, U. of Oklahoma, 2000
B.A. in Philosophy, U. of Oklahoma, 2000



Maximum solar heating occurs at latitudes near the equator, warming the sea surface and causing the surface air to rise. As the air ascends high into the atmosphere, it is replenished at the surface by the northeast trade winds from the north and the southeast trade winds from the south. This area of rising air is associated with deep atmospheric convection, heavy precipitation, and weak mean wind speeds. Early sailors were acutely aware of the tendency for weak winds in this region; they labeled this region the doldrums and carefully avoided it. Today, there is renewed scientific interest in the doldrums, also known as the Inter-Tropical Convergence Zone (ITCZ), because the strength and location of this band of convection exerts a profound influence on global weather patterns. The strength and location of atmospheric convection in the ITCZ is primarily determined by the sea surface temperature (SST) field.

Tom began his Ph.D. thesis research in October, 2004 under the supervision of Dr. Robert Weller. This research utilizes a unique data set of upper ocean and surface meteorology measurements from the eastern tropical Pacific to study the processes important in setting SST in the region. The data are from two WHOI surface moorings on 125ºW, one at 3° S in the equatorial cold tongue (a band of cold water that appears annually on the equator in the eastern Pacific) and one at 10° N near the northernmost climatological position of the ITCZ. This research is an outgrowth of Tom's Master's thesis research, which examined the evolution of the upper ocean thermal structure at the northern site.

This research has yielded insight into a mechanism by which the ocean influences the evolution of SST on intraseasonal timescales at the 10ºN site (Farrar and Weller, submitted manuscript). Prominent meridional current fluctuations with a period of about 2 months were observed in the mooring data, and these current fluctuations exerted a strong influence on the local SST, causing it to fluctuate with about a 2 month period from January-June of 1998. The SST fluctuations associated with this signal were substantial, with peak-to-peak amplitudes ranging from 0.5-0.8ºC. Farrar and Weller showed that the SST fluctuations were caused by horizontal advection along the meridional surface temperature gradient.

The two month signal in meridional currents was linked to a previously recognized sea surface height signal that is strongest in the latitude band 9-13ºN east of 120ºW. To resolve discrepancies in prior studies of the signal, Farrar and Weller also worked to characterize the signal observed at the mooring within its larger spatial and temporal context using satellite SST and sea surface height measurements. The signal was found to be associated with relatively short (5-15º wavelength) baroclinic Rossby waves. Farrar and Weller also found evidence that the intraseasonal velocity variability, and its annual cycle, are caused by instability of the westward flowing North Equatorial Current as it intensifies in the spring of each year. It is hoped that this improved understanding of mesoscale oceanic variability and its impact on SST in the region will allow for improved prediction of the oceanic mesocale SST field at monthly to seasonal timescales. This could be particularly important in the region of 9-13ºN in the eastern tropical Pacific, one of the world's most prolific regions of tropical cyclogenesis.

Continuing progress will allow for the completion of the analysis of the data collected at 125°W during 1997-1998 in conjunction with preparation of Tom's Ph. D. Thesis. The effort has shifted to examination of the surface forcing, upper ocean dynamics, and evolution of the thermal structure at 3°S. With that complete, Tom will use remote sensing and TAO data in conjunction with the upper ocean observations and air-sea fluxes from the two mooring sites to extend the effort to identify the important physical processes that drive the evolution of SST and upper ocean thermal structure over the broader region spanning the equatorial cold tongue and in the eastern Pacific warm pool.

J. Steven Fries, Graduate Student

Steve successfully defended his thesis titled "Enhancement of Fine Particle Deposition To Permeable Sediment" on September 13, 2001. The thesis abstract follows.

Predictions of deposition rate are integral to the transport of many constituents including contaminants, organic matter, and larvae. Review of the literature demonstrates a general appreciation for the potential control of deposition by bed roughness, but no direct tests involving flat sediment beds. Understanding the mechanisms at work for flat sediment beds would provide the basis for exploring more complicated bed conditions and the incorporation of other transport processes, such as bioturbation and bedload transport.

Generally, fine particle deposition rates are assumed to be equivalent to the suspension settling velocity, therefore, deposition rates in excess of settling are considered enhanced. Flume observations of deposition were made using treatments that covered a wide range of flow, particle, and bed conditions. Specific treatments demonstrated large enhancements (up to eight times settling). Delivery of particles to the interface is important, but models based on delivery alone failed to predict the observed enhancement.

This necessitated the development of a new model based on a balance between delivery and filtration in the bed. Interfacial diffusion was chosen as a model for particle delivery. Filtration of particles by the bed is a useful framework for retention, but the shear in the interstitial flow may introduce additional factors not included in traditional filtration experiments.

The model performed well in prediction of flow conditions, but there remained a discrepancy between predictions and observed deposition rate, especially for treatments with significant enhancement. Fluid flow predictions by the model, such as slip at the sediment water interface and fluid penetration into the sediment, appeared to be supported by flume experiments. Therefore, failure to predict the magnitude of enhancement was attributed to the filtration efficiency. A weakness of this deposition model is the lack of an observable mechanism to drive diffusion and filtration. Emerging techniques to directly measure fluid and particle motion at the interface could reveal these mechanisms. The observation of enhanced deposition to flat sediment beds reinforces the importance of permeable sediments to the mediation of transport from the water column to the sediment bed.

Background

Ph.D., MIT/WHOI Joint Program
B.S. in Civil Engineering / Engineering Public Policy (Minor: Environmental Engineering)
Carnegie Mellon University Received December 1994

J. Steven Fries graduate research centered around flume studies identifying the mechanisms controlling deposition of fine particles with a focus on sediment transport, interfacial flows, and permeability at the sediment-water interface. The focus of his doctoral thesis is the observation of enhanced fine particle deposition to flat, sand beds. A simple mathematical model for deposition which incorporates settling of particles, diffusion across the sediment-water interface, and filtration within the sand bed was developed to predict scenarios where deposition maybe enhanced. In addition to his graduate thesis, he has pursued projects involving biological effects on sediment transport. Ripple formation and migration within benthic assemblages changes the near-bed flows and potential for deposition within the patch. He has also worked with fellow students to incorporate the technique of particle image velocimetry (PIV) into flume studies of turbulence and particle deposition.

Summer Student Fellows

Starting in 2005 CICOR has agreed to fund three Summer Student Fellows, one in each CICOR theme, who will participate in the highly competitive Summer Student Fellowships Program. Summer Student Fellowships are awarded to undergraduate students completing their junior or senior year at colleges or universities, studying in any of the fields of science or engineering with at least a tentative interest in the ocean sciences, oceanographic engineering, mathematics, or marine policy. Fellowships are awarded to pursue an independent research project under the guidance of a member of the Scientific or Senior Technical Staff. These projects typically are suggested by the advisor, and are agreed upon jointly by fellow and advisor. Through this program of Summer Fellowship grants, Woods Hole Oceanographic Institution's (WHOI) aim is to give a promising group of science and engineering students experience, which will assist them in determining whether they wish to devote careers to the study of the oceans. The program has been very popular and, consequently, very competitive, with an average of about ten to fifteen percent of the applicants receiving awards.

Fellows are selected on a competitive basis, with final decisions based on the applicant's previous academic and scientific achievements and promise as future ocean scientists or ocean engineers. Important consideration is given to matching each fellow with an appropriate advisor on the Research Staff. The advisor helps the student select and pursue a research project that can provide meaningful results in one summer's work. Fellows are not required to take any prescribed courses, nor are they required to provide any services to the Institution in return for the summer grant. At the end of the summer, each fellow is expected to prepare a written report describing his or her research and to make a public oral presentation of his or her results. Fellows have an excellent opportunity to select and pursue a research problem of their own with access to more than two hundred practicing research scientists and engineers and to the facilities of a major oceanographic institution. In addition, fellows are welcome to participate in the busy summer schedule of seminars and colloquia in the Woods Hole scientific community, which provides an excellent introduction to the many facets of marine science.

Summer Student Fellowships are awarded to undergraduate students who have completed their junior or senior year at colleges or universities studying in any of the fields of science or engineering including but not limited to the fields of biology, chemistry, engineering, geology, geophysics, mathematics, meteorology, physics, oceanography, and marine policy. Students must have at least a tentative interest in the ocean sciences, oceanographic engineering, mathematics, or marine policy. Women and persons from under represented groups are encouraged to apply.

Summer Student Fellowship awards for the summer of 2005 carry a stipend of $396 per week for a ten- to twelve-week program. Additional support may be provided for travel.

The participants for the summer of 2005 will be:

1. Yue (Max) Li (Swarthmore College), to be co-supervised by Peter Wiebe (BIO) and Andore Lavery (AOPE). Peter Wiebe is a WHOI CICOR grant PI.

2. Chryanthi Tsimitri (Aristotle University of Thessaloniki, Greece), to be supervised by Bob Pickart (PO), who is a WHOI CICOR grant PI.

3. Theresa Black (Western Washington University), to be co-supervised by Dina Erdner and Don Anderson (BIO). Dina Erdner is in Anderson's lab and Don Anderson is a WHOI CICOR grant PI.