# R/V *Tioga* Cruise #715
# Cruise Report

## October 21st – 23rd, 2013

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http://bcodmo.org/

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## 2. Acknowledgements

The success of this cruise would not have been possible without the flexibility, proficiency and expertise of Captain Ken Houtler and mate Ian Hanley of the *R/V Tioga*. We are grateful for the efforts of Ann Tarrant and Mike Lowe who assisted with transferring the water collected on the first day to Woods Hole Oceanographic Institution's Environmental Systems Laboratory. This cruise was supported by a grant from the WHOI Coastal Ocean Institute (Wang, Lawson and Maas) and by NSF grant OCE-1316040 (Lawson, Maas, and Tarrant).

## 3. Background

As a result of increases in atmospheric carbon dioxide ($CO_2$), the ocean is taking up extra $CO_2$ and becoming more acidic, in a process referred to as ocean acidification (OA). Certain coastal regions, such as the upwelling system along the U.S. West Coast, are more susceptible to the effects of ocean acidification than others, because their waters are episodically or seasonally naturally higher in $CO_2$ concentration and lower in pH and saturation of aragonite (a calcium carbonate mineral). In such OA 'hot-spots,' continued anthropogenic perturbations to the carbonate chemistry will quickly push the system towards a more corrosive (aragonite under-saturated, $\Omega A < 1$) environment that many calcium carbonate shell-forming organisms may not tolerate. Coastal acidification in the Gulf of Maine (GoME) has generally not been considered to be a pressing concern, but new data (Wang et al. 2013) suggest that in the deep waters of the GoME low seawater pH may cause aragonite saturation states ($\Omega A$) to be close to a chemical and ecological threshold (i.e. $\Omega A = 1$).

This cruise was the last of three cruises in a project that aims to assess seasonal variations of the $CO_2$ system in the deep GoME and the associated impacts on thecosome pteropods. It was also the first of an NSF project to assess the seasonal effect of high $CO_2$ on the local population of thecosome pteropod, *Limacina retroversa*. These individuals are found throughout the year in the GoME and therefore experience fluctuations in their exposure to $CO_2$. By exploring what conditions they experience in situ, and then brining animals back to the lab for metabolic, gene-expression and calcification studies, we can determine whether there are seasonal sensitivities to $CO_2$ exposure.

## 4. Cruise Objectives

The central goal of this cruise was to sample the carbonate chemistry profile of three sites in the GoME, to document the abundance and vertical distribution of the pteropod species *Limacina retroversa*, and to capture live individuals for experimentation. The long-term goal of this research is to understand forcings by climate, enhanced atmospheric $CO_2$ levels, and coastal eutrophication on seasonal and inter-annual variability in carbonate chemistry of the Gulf of Maine and to understand how variations in the natural environment impact the local planktonic calcifiers, specifically the thecosome pteropods. The specific goals are to:

1. Quantify seasonal variations of carbonate system parameters and buffer intensity in deep waters of the Gulf of Maine in order to evaluate the sensitivity of these waters in response to acidification due to anthropogenic forcing, such as increase in atmospheric $CO_2$, freshening of the GoME (decrease in total alkalinity) and increases in water-column respiration due to eutrophication. We will test the hypotheses that deep waters of the GoME are already seasonally under-saturated with respect to aragonite saturation state, and that these waters have low buffer intensity compared to overlying water, which would cause them to be more susceptible to acidification pressures and to reach critical ecological thresholds ($\Omega_A < 1$) more readily.
2. Quantify seasonal patterns in the abundance of the pteropod *Limacina retroversa* and its vertical distribution relative to concurrent measurements of water column chemical properties, testing the hypothesis that this species is absent in the acidic waters of the near-bottom nepheloid layer.

3. Test whether there are seasonal patterns of gene expression, shell quality and metabolic rate linked to seasonal exposure.

4. Determine how experimentally enhanced levels of $CO_2$ influence the gene expression, shell quality and metabolic rate of *Limacina retroversa* that are exposed for a period of 1-14 days in the laboratory and explore whether these responses are mediated by seasonal exposure.

The specific goals of this particular cruise were to:

1. Measure the carbonate chemistry of the water column at multiple sites in the Gulf of Maine, targeting the sites which were sampled during Tioga cruises 668 (May 2013) and 700 (August 2013) to provide a seasonal contrast in the measurements.

2. Measure the carbonate chemistry in the nepheloid layer to provide a seasonal contrast in the measurements.

3. Catch *L. retroversa* with a vertically stratified net system to quantify their size class, abundance and vertical distribution in the context of the carbonate chemistry and season.

4. Collect *L. retroversa* to preserve in ethanol (70%) for shell studies and in RNAlater for gene expression studies to explore the seasonal response to $CO_2$.

5. Collect surface water and *L. retroversa* for live animal laboratory experiments.

## 5. Survey Design

On Friday October 18th the R/V Tioga was packed at WHOI. On Sunday October 20th it left WHOI at ~15:00 to preposition to Provincetown Harbor. The scientific crew followed by car and stayed at Chateau Provincetown. On Tuesday the boat left port at 8:00 am and traveled to our deep sampling site in Wilkinson (Standard station 1) to conduct the full sampling regime (CTD/VPR, MOCNESS, Reeve) and collected water with the little pump for experiments. We started the transit back and paused at standard station 3 for a Reeve net. Upon return we were met at the dock by Ann Tarrant and transferred water to a 55 gallon barrel and to multiple trash cans aboard a truck that she returned to WHOI. The next day we left at 8:00 am and traveled to Murray Basin, an offshoot of western Wilkinson Basin (standard station 2/consecutive station 3 in Fig. 1; ca. 260 m), where we did a full sampling regime and a total of three Reeve nets. We then transited to our shallow station (standard 3/consecutive station 4 in Fig. 1) where we did our CTD and three Reeve nets. That night the chemistry crew (Aleck and Lenna) and Peter Wiebe left for WHOI due to prior obligations. On day 3 we also left at 8:00 am and stuck around station 3 all day and did a lot of Reeve netting. We returned to port at ~17:00 which left time for the R/V Tioga to return to WHOI that evening. The boat was met at the dock at ~21:00 WHOI and the final trash can with water and animals was craned off using the hand-cart as a handle.

Full information about casts and stations can be found in the Event Log (Appendix 1).

## 6. Cruise Narrative

The boat left from the floating ferry harbor both days and was tied up there overnight as well. Ken made arrangements with the harbormaster and parking passes were printed so we were able to park on the dock.

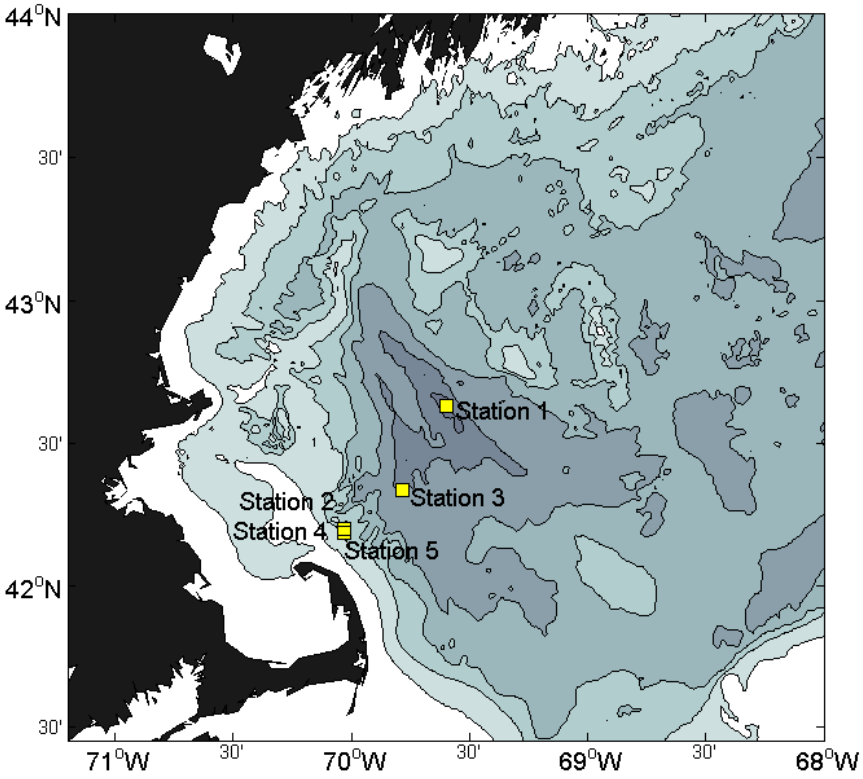



**Figure1 –** Gulf of Maine Map. We sampled extensively at Station 1 (standard station 1) and put in a Reeve at Station 2 on Day 1 (August 27th). On Day 2 we extensively sampled at Station 3 (standard station 2), and put in a CTD at Station 4 (standard station 3) and put in the pump at Station 5. Note that Station 2, 4 and 5 are in approximately the same location.

**Day 1: Monday October 21st**

Monday morning the scientific crew met the R/V *Tioga* at the Provincetown dock and left port at 7:27on August 27th and reached the deep sampling site (Station 1 in Figure 1; ca. 300+ m) after ~ 3 hours. This site was chosen as it has been sampled previously for carbonate chemistry by Wang in 2007 and in May and August of 2013. We have adopted the numbering convention of having a series of standard stations, where Station 1 = the deepest station in Wilkinson, sampled previously by Wang's lab and sometimes referred to previously as Standard Station Aleck, Station 2 = the slightly less deep station in Wilkinson Basin sampled previously by Lawson's lab and sometimes referred to as Standard Station Gareth, and Station 3 = the shallower station to the east of the shipping channel near Stellwagen Bank added during the May 2013 cruise. Then during each cruise we have consecutive station numbers that describe the chronological order in which these standard stations, and any other stations, were occupied. We did our full sampling regime (CTD/VPR, Reeve, MOCNESS). From the MOC we took zooplankton samples from nets 3 and 4 to be stored in RNAlater (see MOC section for details). We then pumped six trash bins of water from ~30 m using the "Little Giant" pump setup (~1 hour). From the Reeve net there were 4 Limacina retroversa of decent size that were put in RNAlater. There were still gastropod veligers of the brown color similar to those found on the previous (Tioga 700) cruise.

We left station 1 at around 16:30 and steamed towards Provincetown. Along the way we stopped at standard station 3 (Station 2 in Figure 1) where we did a Reeve tow that yielded 20 live animals that were set aside and 53 individuals which were preserved in ethanol or RNAlater. We then returned to Provincetown by ~20:45. At the dock we were met by Ann Tarrant and transferred water off the boat via the small pump finishing just in time for Amy and Gareth to have dinner at the Squealing Pig. Ann drove

the water back to WHOI where she and Mike Lowe transferred it into the tank for filtration/UV treatment. Mike then moved the treated water into trash cans for temperature and gas acclimation the following day. Thanks guys!!

**Day 2: Tuesday October 22nd**

Weather was unexpectedly nice on Tuesday. We had expected bad winds and waves as we left Provincetown at 7:10, but we rounded Race Point and all was fair so we traveled out to the site in Murray Basin, an offshoot of western Wilkinson Basin (Station 3 in Figure 1; ca. 260 m), arriving at 9:04. This second site was chosen as it has been sampled for zooplankton by Lawson's lab in 2010, 2011, and 2013. Here we completed a full sampling regime (CTD/VPR, Reeve, MOCNESS), and did a few more Reeve casts. A few animals were put into jars at this station. We headed for standard station #3 (Station 2, 4 and 5 in Figure 1) where we did a CTD/VPR cast and three more Reeves. We started getting quite a few more thecosomes at this point with the Reeves which gave us enough confidence that we could get sufficient animals that we decided to shoot for day 3. On the way in Taylor replaced the ethanol from the 1st days sampling. At port Taylor and Peter went to chat with the hotel before they closed (we kept failing to make it to the front desk when it was open so all prior communication was via cell-phone during transit or via notes left in mailboxes) and went to Stop and Shop to buy more jars. After returning Taylor to the crew, Peter left for WHOI. Dinner was, once again, at the Squealing Pig. Aleck and Lenna left for WHOI after dinner.

Upon reaching port, cold packs were put into the one cooler with pteropods and transferred to Amy's car, where they were then taken to ESL. Gareth and Amy put the animals into the incubation that evening and set up for the respiration experiment, which was scheduled for the next day.

**Day 3: Wednesday October 23rd**

Amy's car stopped and picked up some ice from the gas station prior to breakfast Wednesday morning to keep water samples cold. The weather continued to be pleasant and with at 6:57 departure from P-town we were on station at 8:05. We then Reeve netted like there was no tomorrow. After 8 tows we had more animals than was required (~1200 largish animals) and a trash bin full of small individuals. The estimate is at ~2000 fresh animals. We returned to port at ~17:00, giving Ian and Ken enough time to get back to WHOI. The science crew had dinner at Provincetown Pizza (really nice veggie pie and lovely variation on a Polynesian) and drove back to WHOI. Amy dropped off Andrea and Taylor at Redfield then headed to ESL where Phil Alatalo was waiting to help deal with animals. Gareth and Alex met up with the ship and got the trash can of pteropods off the boat and moved up to ESL.

## 7. Equipment Configuration

### 7.1. *Deck configuration*

The collapsible plastic crate with 4 garbage cans was strapped down to the starboard side of the back deck. The Reeve net was stowed on the aft side of the pallet with the ring through the band and the bucket bungeed on. The MOCNESS was tied down on the starboard aft, the CTD, with associated VPR on its stand was positioned mid-ship (Fig. 2A). We used the same cable for all deployments. When the back deck space was needed for other deployments the CTD was moved to the forward port side of the deck (Fig. 2B). There was a table with a built in sink bolted down at the forward port portion of the back deck that could be plumbed with a seawater line from the R/V Tioga's sea chest (Fig. 2C). The ethanol was strapped down furthest aft of this table to allow for easy jar filling. Under the sink were the coolers full of jars for live animals and a tote containing the MOCNESS sample processing gear. During CTD processing this space also contained sample bottle totes. Another tote was strapped in the center of the ship for sample jars for ease of net processing. The two extra trash bins were strapped to the middle port side, catty-corner to the sink/table (visible in Fig. 2B). The generator for the large pump (which did not

get used) was tied down near the starboard side of the winch spool, while the rest of the pump, including the hosing, was tied down on the forecastle (fo'c's'le; Fig. 2D).

### 7.2. *Lab configuration*

The main lab aft counter housed the laptop which was used for event logging, TDR attempted setup and VPR processing. The starboard counter had MOCNESS sampling supplies and chemistry sampling equipment and a portable plug-in freezer. On the floor was more MOCNESS backup/sampling equipment. The rest of the backup supplies, foul weather gear and personal belongings were at midship and in the port bunk space. The MOCNESS computer unit was housed in the wheelhouse. There was quite a bit of extra space in the lab to support other projects.

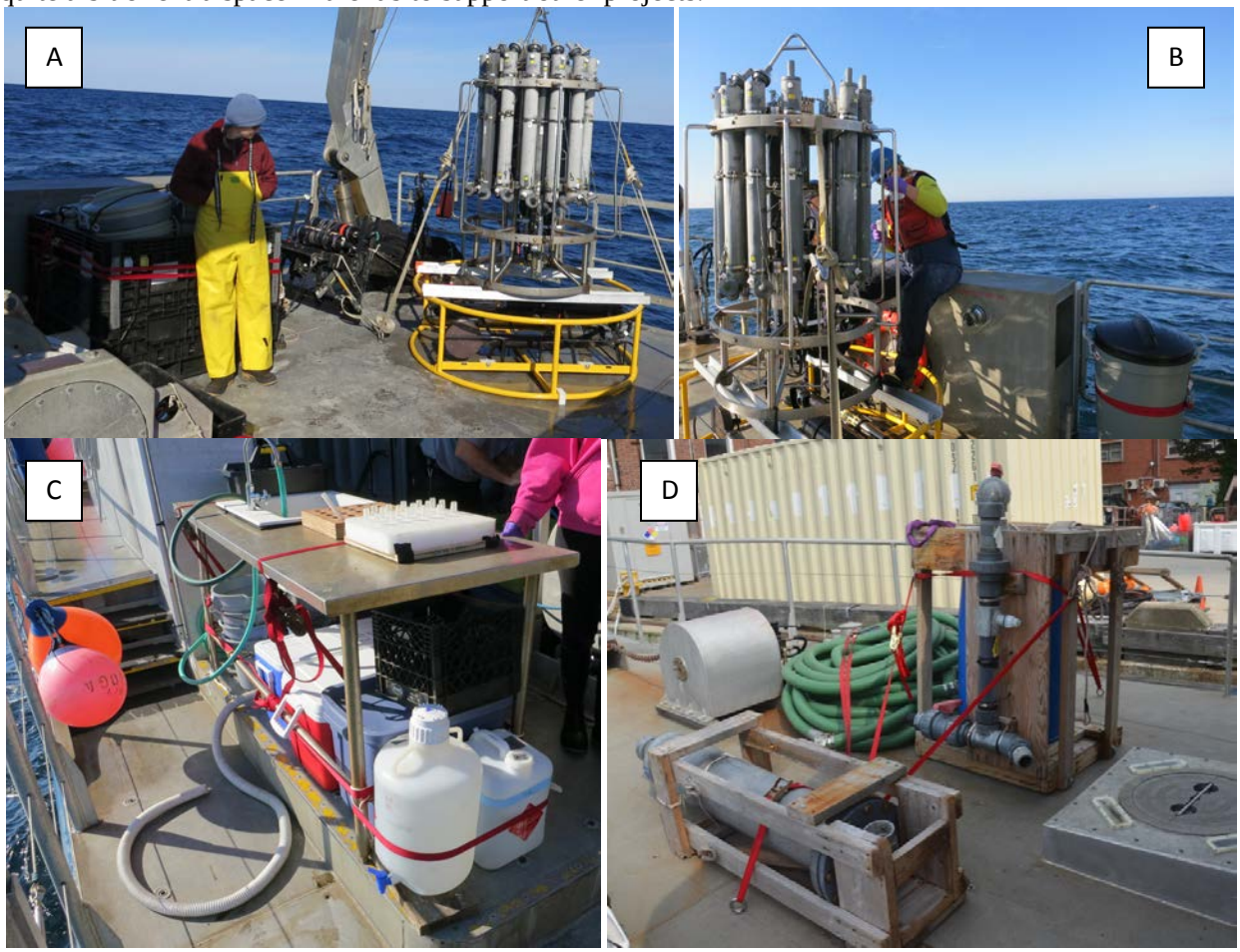



**Figure 2** –A) Configuration of the back deck featuring the VPR on its modified housing below the CTD, the ¼ m MOCNESS on the starboard side, and the collapsible pallet containing the four trash bins. The Reeve net was strapped to the aft part of the collapsible pallet (not shown here). When the back deck was being used for other things the CTD was moved forward and to the port side. This is also where the extra trash cans were strapped down. C) The sink was set up on the port side of the back with the ethanol on the outside for ease of access. The in-use carboy was propped up on a piece of wood. D) Configuration of the starboard side of the forecastle with the gear associated with the large pump, excluding the generator Photos by: Peter Wiebe

## 8. Hydrography: CTD

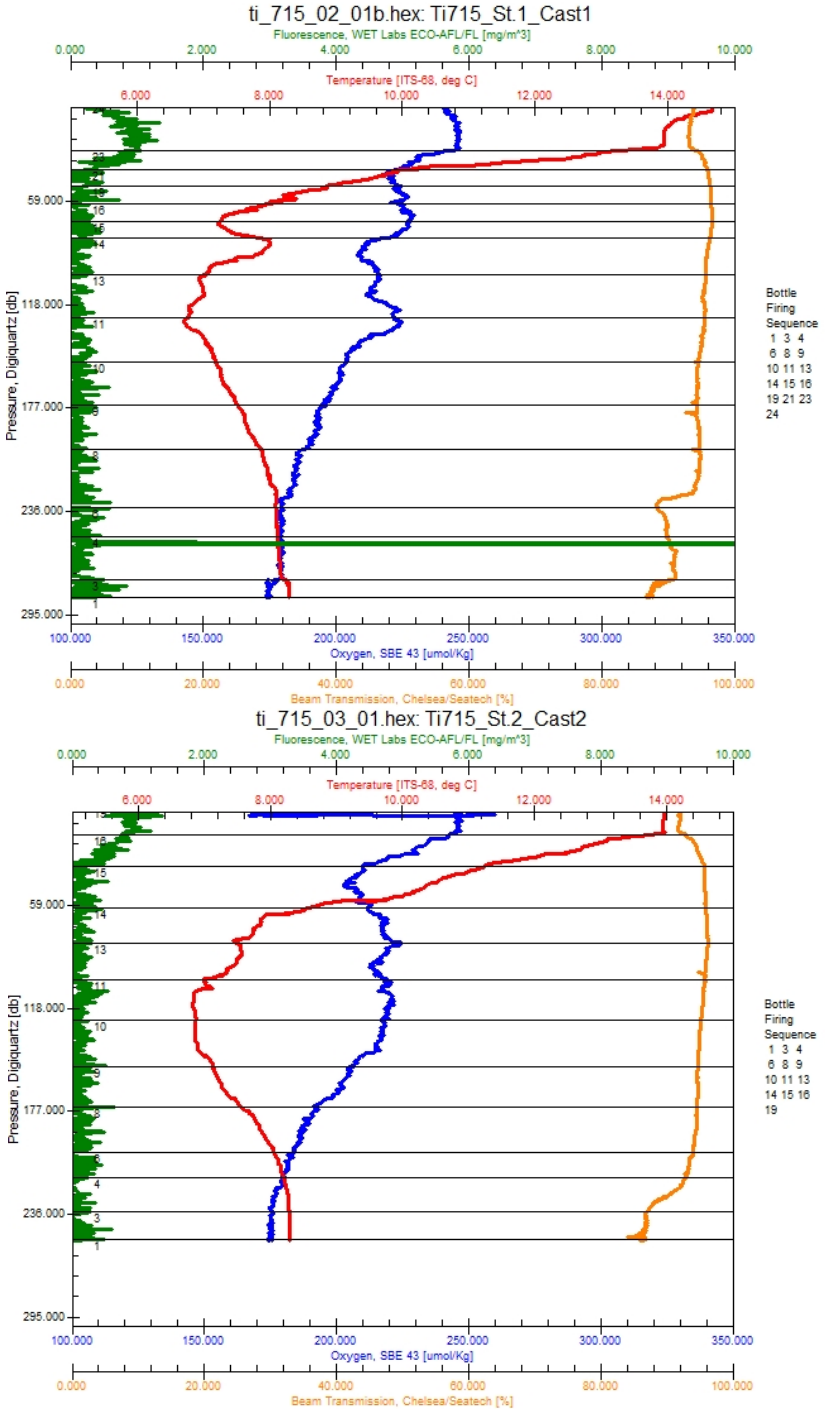
### 8.1.1. Introduction

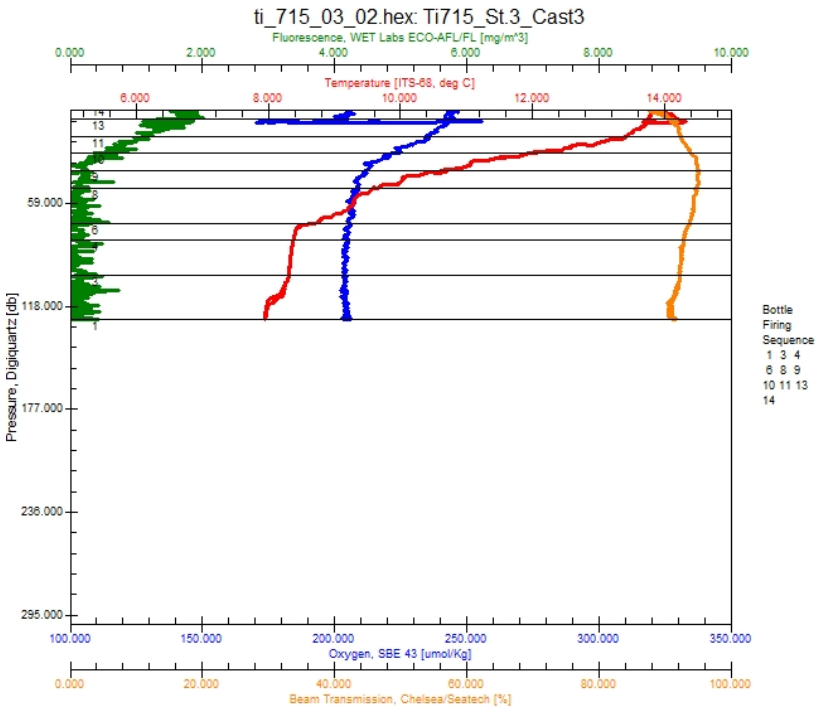
CTD rosette casts were the focus of the chemistry team aboard this trip as profiles of the water column provided a snapshot of the nepheloid layer and Niskin bottle sampling provided water for the carbonate chemistry analysis. These CTD measurements of environmental conditions provided key correlates of the distribution and abundance of pteropods. Depths were chosen to characterize the bottom nepheloid layer (BNL) and then to continue at pre-designated intervals throughout the rest of the water column..
The typical protocol for the CTD is to sample upper 100m at 10 m intervals, 100-200m at 20 m intervals, and less frequently below. On the R/V Tioga this needs to be modified as we have limited numbers of bottles, and funds to analyze the samples. At the deep station (i.e. Standard Station #1, Station #1 on TI715) one bottle is fired at the bottom of the cast (i.e. ca. 5 m off bottom), one at the top of the BNL and then 2-3 bottles at depths aimed at capturing regions of variability in transmission. Then from 200m to the surface, bottles are fired in approximately 20m increments, with some discretionary changes in interval size to target interesting features in light transmission or dissolved oxygen DO (or presumably salinity) resulting in a total of 16 bottles. At the somewhat shallower station (i.e. Standard Station Gareth/#2, Station #3 on TI715), 13 bottles were fired at regions, again based on varying transmission within the NBL and discrete increments in the upper water column. Finally at the near-shore station (i.e. Standard Station #3, Station #2, 4 and 5 on TI715), the water depth necessitated only the firing of 10 bottles. For this cruise, George Tupper and company added 4 bottles to the rosette, for a total of 16 bottles. This allowed the full water column to be sampled at even the deepest station with just one cast, rather than via two casts as has been the case on previous cruises. The rosette release mechanism is now a 24-place, however, which resulted in a somewhat complicated assignment of bottles (numbered consecutively from 1 to 16) to release position; Ian and Taylor thus had to be careful in cocking the bottles to get this assignment correct each time.

### 8.1.2. Methods

The R/V *Tioga* CTD rosette had a16 bottle rosette with 3-L Niskins, and a SBE3/SBR4 sensor set. CTD casts were conducted of the full water column at standard station 1 on day 1 and at standard stations 2 and 3 on day 2.

## 8.1.3. Preliminary Results






# 9. Chemistry

## 9.1. *Introduction*

Dr. Zhaohui Aleck Wang's group from the Department of Marine Chemistry and Geochemistry at WHOI collected discrete bottle samples of seawater for later measurement of carbonate chemistry parameters. Measuring these parameters allows us to calculate pH, the carbonate compensation depth and the calcium carbonate saturation state, three important variables that may influence the formation of aragonite shells by pteropods.

## 9.2. *Discrete Measurements of Dissolved Inorganic Carbon and Total Alkalinity*

### 9.2.1. Methods

Discrete dissolved inorganic carbon (DIC) and total alkalinity (TA) samples were collected from 3 stations from the surface to near-bottom. Depths were chosen adaptively to target chemical features of interest while also attaining reasonably even coverage of the water column (See CTD Methods). DIC and TA samples were collected in 250mL Pyrex borosilicate glass bottles after being filtered with a 0.45um in-line capsule filter. Each bottle was rinsed three times, filled completely, and then the sample was overflowed by another one and one half bottle volume. Air head space of about one percent of the bottle volume (~3 ml) was left in each sample bottle to allow room for expansion. Each sample was then poisoned with 80uL of saturated mercuric chloride, capped with an Apiezon-L greased stopper, thoroughly mixed, and then tied with a rubber band over the glass stopper. Duplicate samples were collected at random depths of selected stations to evaluate the precision of the measurements. These samples will be measured for DIC and TA back in the Wang Lab at WHOI.

## 9.3. *Discrete Nutrient Measurements*

### 9.3.1. Methods

Nutrient samples were collected in acid cleaned Kimble 20mL plastic bottles. Before the cruise, the bottles were soaked in 10% hydrochloric acid for four hours, rinsed three times with deionized water, and

then dried in the oven at 50°C for 48 hours. During collection, the sample was filtered with a 0.22um Pall capsule filter. The bottle was rinsed three times with the sample and then filled. Collected samples were put into the plug-in freezer aboard ship immediately upon collection. When the R/V *Tioga* reached WHOI these samples were taken to the WHOI Nutrient Analytical Facility for analyses. Concentrations of ammonium, nitrate plus nitrite, nitrite, orthophosphate, and silicate will be determined by a Lachat Instruments QuickChem 8000 four-channel continuous flow injection system, using standard colorimetric methods approved by U.S. Environmental Protection Agency.

## 10. Zooplankton Sampling

### 10.1. *MOCNESS*

#### 10.1.1. Introduction

A standard 1/4-$m^2$ Multiple Opening/Closing Net and Environmental Sensing System (MOCNESS; Wiebe et al., 1985) was used to collect zooplankton to determine the vertical distribution and abundance of the thecosomatous pteropods.

#### 10.1.2. Methods

The MOCNESS was equipped with nine 150-um mesh nets (nets 0-8). The underwater unit used was #169; temperature probe was #535 and conductivity probe was #120. In addition to the standard temperature and conductivity probes the system also had a beta-type strobe-light unit for reducing avoidance of the nets by some zooplankton and possibly small fish. The strobe system has two units each with 12 LED sets (LUXEON Rebel LED) with peak output between 490-520 nm. The LEDs are powered by the MOCNESS battery and their pulse width, amplitude, flash rate period, and on/off are controlled by the MOCNESS software.

The MOCNESS was deployed from the aft winch and A-frame. Upon recovery the nets were all hosed down with seawater and the cod-ends were sequentially removed, placed in buckets, and transferred to the forward sink and table. Net contents were preserved in 70% ethanol.

Oblique casts with the MOCNESS were made to ca. 5 m off bottom (based on the Knudsen echosounder on the ship's depth estimate) with a ship speed nominally of 2 kts. Sampling occurred consistently for the top 5 nets which were taken at 150-100, 100-75, 75-50, 50-25, and 25-0 m. The bottom two nets were chosen adaptively to cover the lower water column and ensure that the lowest net occurred exclusively in the nepheloid layer (see Appendix 3- for sampling sheets). Cast depth has been to 10m off bottom. Typically there has been a region of fairly constant or gradually changing transmission at the bottom of the BNL, with a region of steeply changing transmission at shallower depths, ending at the top of the BNL where transmission levels off. The protocol has been to sample with net 1 from the max depth to the top of the region of constant/gradually changing transmission and then with net 2 from there to the top of the region of steeply changing transmission (i.e. to the top of the BNL). All samples had the ethanol replaced with fresh 70% ethanol ~24 hours after sampling.

#### 10.1.3. Animal sampling

During the 1st MOCNESS animals were sampled from the nets for gene expression analysis. From net 4 ca. 50 copepods (presumably mostly *Calanus finmarchicus*) were taken. These were rinsed in DI water and then preserved in RNAlater for Dr. Ann Tarrant. In net 3 a number of *Meganyctiphanes norvegica* and some incidental *Calanus finmarchicus* were transferred to RNAlater because they are interesting. These samples are in the Tarrant -20 freezer room 212 WHOI.

### 10.2. *Video Plankton Recorder*

Modified from OC473 *Nancy Copley, Alexander Bergan*

### 10.2.1. Introduction

The Video Plankton Recorder is an underwater video microscope system designed to record images of plankton ranging in size from less than one half millimeter up to a few centimeters. A strobe light flashing at 20 times per second captures images at this rate. A program called AutoDeck reviews the images at about 15 frames per second and extracts Regions of Interest (ROIs) that may be plankton based on certain parameters such as brightness and sharpness (see Settings for ROI Extraction below). We used the Video Plankton Recorder (VPR) in order to describe the abundance and vertical distribution of plankton taxa at standard station 1 on day 1 and standard station 2 and 3 on day 2. For this cruise a stand was adapted which allows the VPR to be strapped onto the R/V *Tioga* CTD for simultaneous sampling (more details in Appendix 2).

### 10.2.2. Methods

The VPR was deployed simultaneous with the CTD. The hard-drive was removed following the set of two casts at Station 1 and after each cast at the other stations, and the data was extracted to provide information relevant to the depths targeted by subsequent Reeve net tows.
Recommended Settings for ROI Extraction:
Segmentation threshold **0; 140** (brightness)
Focus: Sobel: **40**; Standard deviation: 1**0** (edge detection)
Growth Scale: **300** (extra area around object)
Minimum blob size: **10** (object size)
Minimum join distance: **1** (distance between objects)

Preliminary Results: No ROIs of pteropods were extracted from the VPR tows, making it unlikely that any pteropods were ever in any of the image frame of the VPR. Most ROIs were of copepods, and a few ROIs were formed from gelatinous organisms, salps and a ctenophore.

## 10.3. *Reeve Net*

### 10.3.1. Introduction

The objective of Reeve net sampling was to gently collect live specimens to be sampled for physiological and genetic analyses. These trawls were short in duration and aimed to maximize pteropod catch.

### 10.3.2. Methods and Approach

A 1-m diameter Reeve net with a 150-um mesh net was deployed via the A-frame. The book-clamp to attach the net was borrowed from the rigging shop. Ship speed during tows was ~1-1.5 knots. This was somewhat unsuccessful on days 1 with some improvement on day 2 but the art was perfected on day three. We eventually maximized wire time to coincide with the amount of time it took to pick thecosome pteropods from the catch. By the end of day 3 this was around 30 minutes of wire time for ~120 large-ish bugs.

The final tactic was to send the wire out fast (15 m/min) to avoid salps and shorten the time and then to park the net at 80, 70 , 60 and sometimes 50 for ~10 or 5 min at each depth, and then pull 15 m/min to the surface. (See Appendix 4 for more details)

On the bench installed on the back deck, the cod end was promptly divided among a number of buckets. Since pteropods tend to sink, the bottom buckets were examined first. To avoid the salps (which were legion) the bucket sometimes had to be diluted. The contents were then swirled and the pteropods sucked up of the center of the bottom using a plastic pipette. These were then concentrated, again taking advantage of the pteropod tendency to sink, and then sorted through to avoid taking other gastropod

veligers and to create two size classes – the "large" (big enough for respiration experiments) which were put into pre-cleaned glass jars and the "small", which were tossed into a trash can with filtered seawater.

#### 10.3.3. Preliminary Findings

The first Reeve net (at standard station 1) had only a few *Limacina retroversa* (65 m?). Four of these were put into RNAlater. The second reeve net (at standard station 3, ~30 m?) had many (~73 medium and a number of small). 53 of the medium sized individuals were put into RNAlater and ethanol, while 20 were kept as live animals. On day two, at standard station 2, tow 3 got 60 medium and 85 small individuals (~60 m?). Tow 4 malfunctioned (twist in the net), and tow 5 did not have any appreciable number of individuals. We then moved to station 3 where we tried a shallow tow (#6, 25 mwo) which did not get many animals. Tow 7, which went deeper (75 m?) retrieved a number of individuals (120 medium and 222 small). Tow 8 went even deeper (90 m?) but did not get that many more animals (69 medium and MANY small). On day 3 we sat at station 3 and towed the net 8 times. We finally settled on a pattern of down at 15 m/min to 80mwo, sit for 10 min then up to 70 mwo at 5 m/min, sit for 10 minutes then up to 60 mwo at 5 m/min then to the surface at 15 m/min. The speed on ascent and descent is because we had a lot of difficulties with salps (blue, chain forming). At the end of the collection we had ~1200 medium animals and more than 1500 very small or day old individuals which were kept in one of the trash cans for culturing/video experimentation.

#### 10.3.4. Difficulties

We ended up not having enough clean glass jars for animals. To rectify this situation Taylor and Peter stopped by Stop and Shop the 2nd evening and bought ball canning jars. To help keep these cool Amy bought ice and we used the ice packs and extra cooler brought by Ann Tarrant on Day 1. We should have filled all of the jars at the start of day 3 with fresh filtered water that was cool instead of using the water left over from day 1 which had warmed. There is some concern that the animals had too many temperature fluctuations –being placed in warm water that was then chilled with ice.

## 11. Pumps

### 11.1. *"Little Giant" Pump*

#### 11.1.1. Introduction

The objective of the "Little Giant" pump was to retrieve water from depth for animal culture. This goal is to have large amounts of water of the appropriate salinity, DIC/TA and temperature to replicate the conditions the animals experience in situ. To achieve this, six "pteropod ptransporter" garbage cans were brought onboard and held in a plastic cage.

#### 11.1.2. Methods and Approach

First 100 feet of heavy duty hose (2 lengths) was lowered into the water attached to the winch line. At intervals a carabineer had been attached to the hose with electrical tape and then affixed to the hose to keep the hose close to the line. Once the hose was at depth (we aimed for 30 m) the pump was attached. The pump was a "Little Giant" subpump with a watertight spliced extension cord. Another hose was attached to the outflow of this unit. The pump was lowered until just below the surface using a safety line, lashed down and then turned on. The outflow hose was strapped to the trash barrels using clamps and filtered through a 63 micron sieve.

When we got to port we transferred water from two of the four to a 55 gallon drum which had been driven to Provincetown by Ann Tarrant in a WHOI truck. The truck pre-positioned on the dock and then we dropped the pump directly into the trash bins and extended the 100 feet of hose via the outflow to the truck. We filled up a 55 gallon drum and four trash bins on the truck. One trash bin was left with filtered

water for pteropods. This warmed drastically over the next few days and was eventually replaced, using the same method, on day three.

## 12. Cruise Participants

Science Party

| | | | | |
|---|---|---|---|---|
| 1 | Amy Maas | Chief Scientist | WHOI | Biology |
| 2 | Gareth Lawson | Scientist | WHOI | Biology |
| 3 | Zhaohui 'Aleck' Wang | Scientist | WHOI | Chemistry |
| 4 | Andrea Schlunk | Guest Student | WHOI | Biology |
| 5 | Alex Bergan | Graduate Student | WHOI | Biology |
| 6 | Taylor Crawford | Research Assistant | WHOI | Biology |
| 7 | Peter Wiebe | Scientist | WHOI | Biology |
| 8 | Lenna Quackenbush | Guest Student | WHOI | Chemistry |

Officers and Crew

| | | |
|---|---|---|
| 1 | Ken Houtler | Captain |
| 2 | Ian Hanley | Mate |

## 13. References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