R/V *Tioga* Cruise #668
Cruise Report

May 21st – 22nd, 2013

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Report available at:
Biological and Chemical Oceanography Data Management Office
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http://bcodmo.org/

Coastal Ocean Institute Grant (PIs: Wang, Lawson, and Maas) "*Acidification of the Coastal Ocean: Are deep waters of the Gulf of Maine already corrosive to pteropods?"*

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2. Acknowledgements

The success of this cruise would not have been possible without the outstanding efforts of Captain Ken Houtler and mate Ian Hanley of the *R/V Tioga*. We are grateful for the efforts of Nancy Copley who helped packing up cruise supplies and for the last minute phytoplankton culturing, ESL advising and loan of a book-clamp, TDR, and flow meter from Phil Alatalo. This cruise was supported by a grant from the WHOI Coastal Ocean Institute.

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 (ΩA) to be close to a chemical and ecological threshold (i.e. $\Omega A = 1$). Currently, there are no year-round CO_2 system measurements to assess conclusively whether the deep waters in the GoME are already experiencing seasonal ΩA under-saturation. If seasonal under-saturation is present, however, this may have detrimental consequences to thecosome pteropods, a group of aragonite shell-forming zooplankton that are important members of the pelagic food web and key contributors to biogeochemical cycles. This project aims to assess seasonal variations of the CO_2 system in the deep GoME and the associated impacts on thecosome pteropods.

4. Cruise Objectives

The central goal of this cruise was to sample the carbonate chemistry profile of two sites in the GoME and to document the abundance and vertical distribution of the pteropod species *Limacina retroversa.* 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 the associated implications to planktonic calcifiers, notably pteropods. The specific goals of this project 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.

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 regions where there the depth is greatest and the deep waters are mostly likely to be undersaturated

2. Measure the carbonate chemistry in the nephloid layer

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

4. Collect surface water and pteropods to test out methods for shell (70% ethanol), physiology (live) and gene expression studies (RNAlater).

5. Survey Design

The Tioga came in to WHOI Friday May 17th for packing, and prepositioned to Provincetown Harbor on Monday the 20th of May. The Tioga left port at 7:00 on May 21st and reached a sampling site in the deepest portion of Wilkinson Basin (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. We did our full sampling regime (CTD, VPR, MOCNESS) and then returned to Provincetown. The next day, May 22nd, we traveled out to a site in Murray Basin, an offshoot of western Wilkinson Basin (Station 2 in Figure 1; ca. 260 m), where we completed a full sampling regime and additionally conducted a Reeve net tow. This second site was chosen as it has been sampled for zooplankton by Lawson's lab in 2010 and 2011. On the way back into Provincetown we stopped at two other stations. Station 3 was the site of a Reeve net cast, while station 4 was the site of a CTD (Figure 1). Full information about casts and stations can be found in the Event Log (Appendix 1).

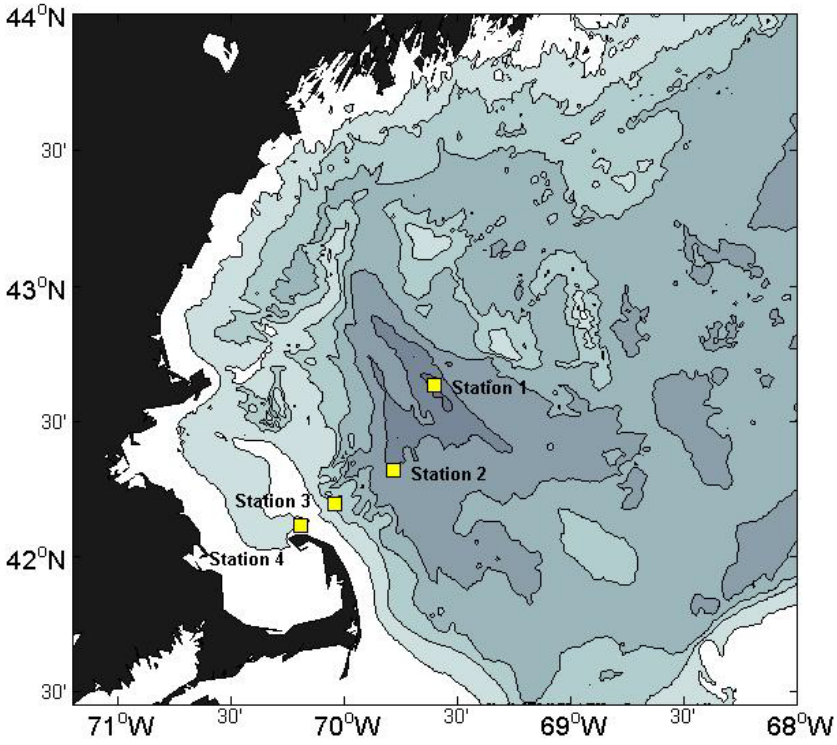


Figure 4.1 – Gulf of Maine Map. We sampled at Station 1 on Day 1 (May 21st) and at all other stations on Day 2 (May 22nd).

6. Cruise Narrative

Day 1: Tuesday May 21st, 2013

Monday's prepositioning of the boat to the Provincetown harbor and the scientific crew to Chateau Provincetown allowed for an early (7:00) arrival at the boat and a speedy early departure. Weather was cloudy, cool and seas had an increasingly high swell as we moved offshore (to a maximum of about 6 ft and an average of about 4 ft). Underway we cocked the CTD. When we reached site we made a CTD cast to determine the structure of the water column and took a few bottle samples. When the CTD came to deck Amy and Taylor quickly taught the new scientific crew the method of collecting DIC/TA samples followed by nutrient samples as Katherine and Aleck poisoned the samples and directed the process. The CTD was redeployed firing 12 bottles and the rest of the samples were taken of the water. The VPR was then connected to the cable and a cast was made. At this point seasickness among the scientific crew became problematic. After the VPR the 1/4-m^2 MOCNESS with strobe was deployed but there was a communication error on the way down. The voltage was reading 0 with a red background, indicative of a strobe malfunction and we pulled the nets back in, and disconnected the strobe. From Net 0 of Moc 1, Amy took a split and put 6 individuals into RNAlater. We then re-deployed the MOCNESS which successfully completed a full tow. Rather than the typical method of dividing the water column up into evenly distributed strata for sampling with the MOCNESS, in this case we selected adaptively the depths of the deepest two nets such that the deepest one sampled cleanly within the bottom nepheloid layer (as determined by a layer of low beam transmission on the CTD's transmissometer) and the next one sampled in the region of rapidly varying beam transmission immediately above. Gareth and Mike washed down nets and secured the MOCNESS while Taylor and Amy finished splitting the samples which were stored in ethanol. This had to be done on the deck of the ship rather than the table due to a crosswind during travel. The top two nets (0-25 and 25-50) were very full of phytoplankton and jellies forcing us to use quart jars. Once the MOCNESS and splits were secured we sped up and headed back to port.

Day 2: Wednesday May 22nd, 2013

Katherine did not come out on Wednesday. Gareth, Amy and Mike arrived at the boat ~30 minutes early to remove the strobe canister, replace the blown little (5A) fuse in the MOC underwater unit, and generally check the MOCNESS. The canister had a bit of water between the seals but otherwise looked fine. The MOCNESS appeared to be functioning well, so at around 7:15 we left port. The morning started a bid damp, foggy and choppy but it improved throughout the day. Seasicknes was significantly less problematic as the day wore on. Underway we re-cocked the MOCNESS and set up the CTD. We reached Wilkinson Basin after about 2 hours and deployed the CTD which fired all of its bottle samples on the first cast. Aleck directed sampling and poisoned as Taylor, Amy and then Camille took water. During this time we put the VPR in and did a full cast. Once the splitting and VPR was completed the MOCNESS was deployed. During the cast we took the seawater hose from the Tioga and used a 150 micron sieve strapped to the trash buckets with two clamps (provided by the Tioga) to filter local seawater for ESL experiments. There was quite a bit of planktonic life in the hose line which we had not taken into account when using the hose line for splitting on the previous day. By the time the MOCNESS was back on board all four garbage cans were >3/4 full. Gareth, Taylor and Camille washed down the nets while Amy taught Mike and Aleck to split the samples, and we were careful to use only 150-sieved water for splitting. Net 0 was processed last and was split to look for live animals, but none were visible so all parts were put into ethanol. During splitting, Amy set the TDR for the Reeve and then Gareth and Amy deployed it. The first cast was made above the phytoplankton layer (as indexed by the chlorophyll max evident in the CTD's fluorometer data) and did not yield much (3 large individuals were put aside for live experiments, and 2 large were put into RNAlater). On the second deployment we had trouble getting the Reeve cod end to fall on the same side of the wire as the ring and had to bring it aboard twice before we got it situated. This cast went into the phytoplankton layer and was packed with animals. Once the Reeve was aboard Amy spent the remainder of the trip picking out ~150 smallish adult individuals which were put into 1 l jars full

of filtered seawater from the site at densities of 10-15 animals jar^{-1}. Also ~3 adult animals and a huge number of very small juveniles/veligers were put in RNAlater. A set of small juveniles/veligers were put in one of the trash carboys in case they were of interest to Scott Gallager. Everyone else tied down the equipment and packed up for the return to WHOI. On reaching shore the live animal jars were put in a cooler with ice packs and taken to shore for transport back to WHOI in Amy's trunk. We reached Provincetown by around 1700, had dinner and headed back to WHOI. The biology team met the boat at around 2100 and craned off the garbage cans of water which were then transferred to ESL. Gareth and Mike and Camille moved the water into 12 L carboys while Amy set up equipment. Taylor replaced the ethanol in all of the samples in Redfield.

Day 3: Thursday May 23rd, 2013
The boat was emptied of gear and the process of cleaning and stowing commenced.

7. Equipment Configuration

7.1. *Deck configuration*

The collapsible plastic crate with 4 garbage cans was strapped down to the port 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 VPR was on the port aft and the CTD was midship. We used the same cable for all deployments and there was a table with a built in sink bolted down at the forward starboard portion of the back deck. The sink could be plumbed with a seawater line from the Tioga's sea chest. A large freezer (-20) was in the forward port position which held the freezer packs, nutrient samples, and RNAlater sampling supplies.

7.1. *Lab configuration*

The main lab aft counter housed the laptop which was used for event logging and TDR setup. The starboard counter had MOCNESS sampling supplies and chemistry sampling equipment. On the floor were the sample jars and more MOCNESS backup/sampling equipment. The rest of the backup supplies, foul weather gear and personal belongings were at midship and in the starboard 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 7.1.1 - Configuration of the starboard side of the back deck. Farthest Aft was the VPR. The Reeve net was strapped to the collapsible pallet containing the four trash bins. Behind the winch was the -20 freezer.
Photos by: Camille Pagniello

Figure 7.1.2 - Configuration of the port side of the back deck. Aft was the 1/4-m^2 MOCNESS, center was the CTD and forward was a stainless steel table with splitting supplies. This table was also where carbonate chemistry samples were processed and poisoned. Photos by: Camille Pagniello

Figure 7.2.1 - Configuration of the lab. The equipment did not take very much space below-decks, and the only thing in the wheelhouse was the MOCNESS/CTD computer. Photos by: Camille Pagniello

8. Hydrography: CTD

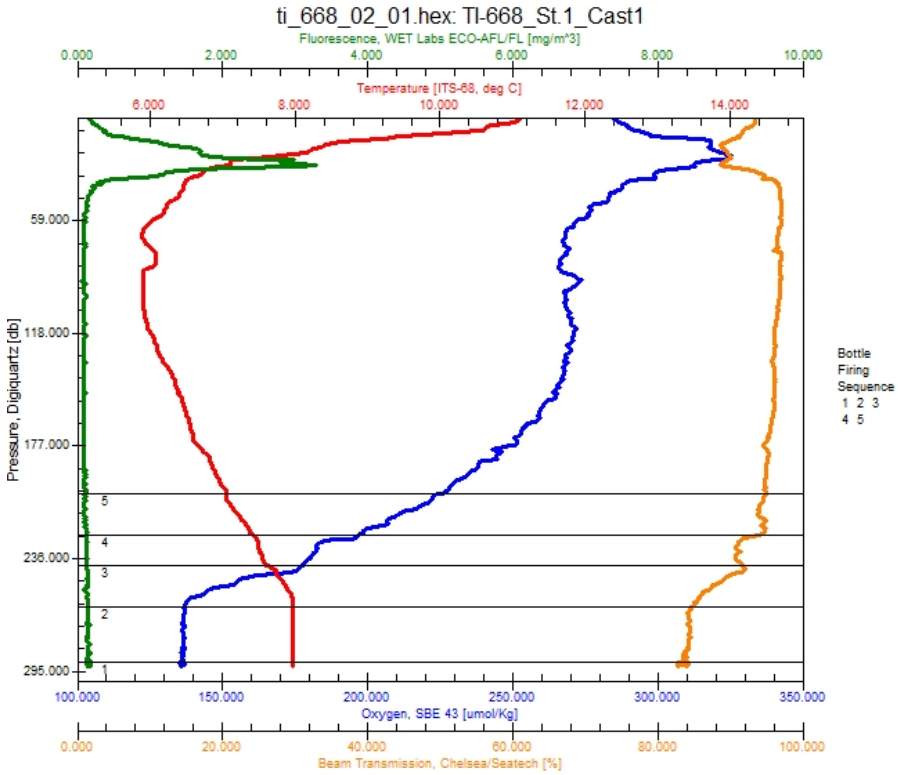
8.1.1. Introduction

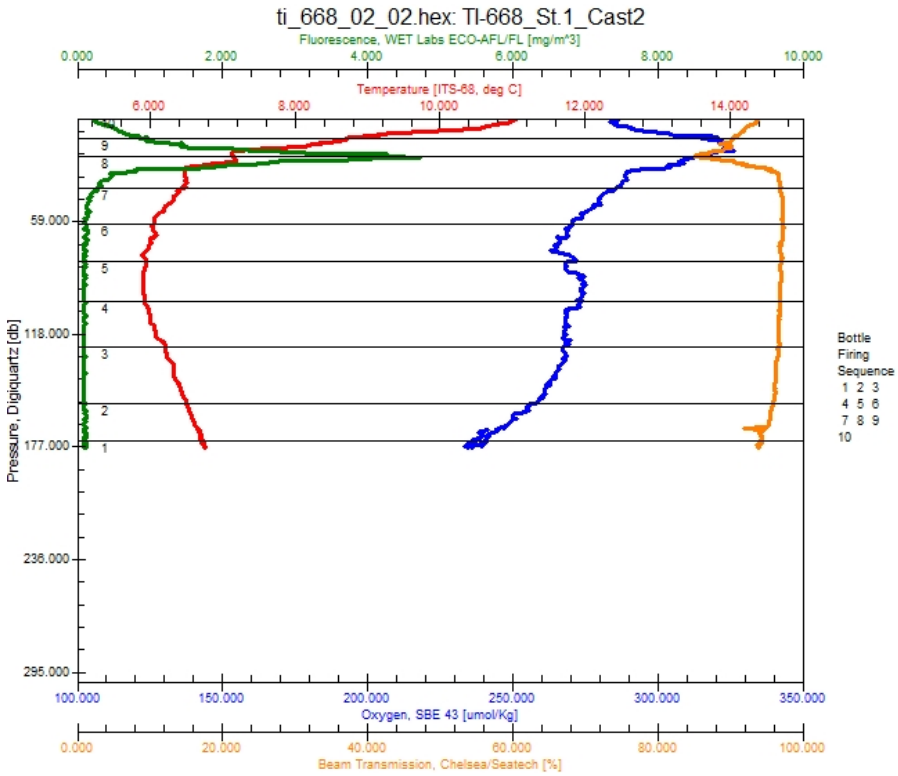
CTD rosette casts were the focus of the chemistry team aboard this trip as profiles of the water column provided a snapshot of the nephloid layer and Niskin bottle sampling provided water for the carbonate chemistry analysis. These CTD measurements of environmental conditions provided key correlates of the distribution and abundance of pteropods.

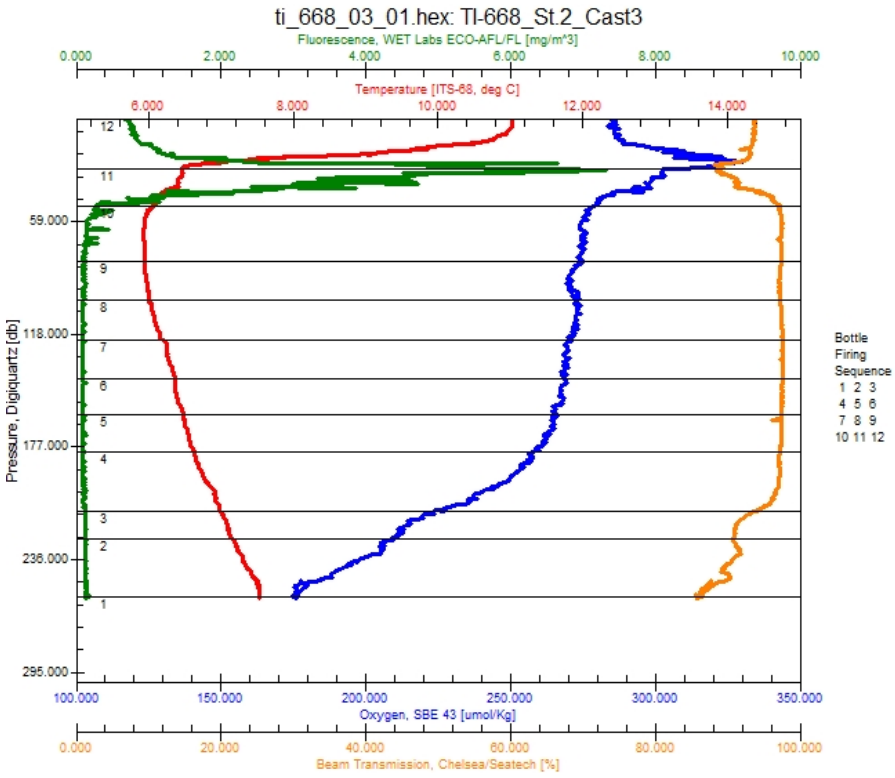
8.1.2. Methods

The Tioga CTD rosette had a12 bottle rosette with 3-L Niskins, and a SBE3/SBR4 sensor set. CTD casts were conducted of the full water column twice at station 1 on day 1 and once at station 2 and 4 on day 2.

8.1.3. Preliminary Results



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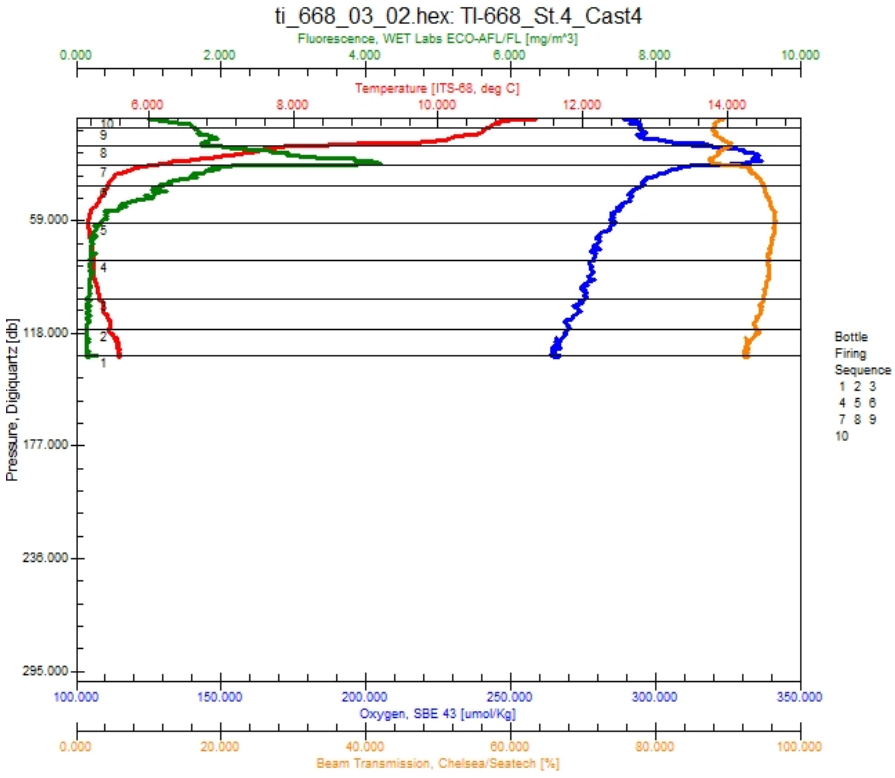
10 11 12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Bottle Firing Sequence
1 2 3
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10

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. The sampling strategy was to capture water from major vertical changes, such as the thermocline, oxygen maximum, chlorophyll and nephloid layer. In addition, vertical sampling resolution was at least 20m. 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 frozen onboard the ship and were taken on ice 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. A connector cable converting from the 4-pin Seacon connector at the wet end of the 0.322" EM cable on the Tioga's winch to the 2-pin EO connector required by the MOCNESS was required. Both the MOCNESS and CTD required the same

pins and so the dry end connectors needed to be swapped out between operations. To simplify this change over, for this cruise, Captain Ken Houtler had a new connector made for the wheelhouse, connecting the ground and first pin wires in the wheelhouse junction box to a BNC connector. The MOC or CTD deck units were then connected to this BNC. 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 5A fuse in the underwater unit that connects to the strobe blew on the first net cast and the canister was subsequently disconnected from the system. The strobe system was removed from the MOCNESS the morning of day 2 since it was not being used.

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 0 was split and half was examined for *Limacina retroversa*, which were put in RNAlater and the remainder of the modified split was subsequently also stored in 70% ethanol. For all other nets, whole samples 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 nephloid layer (see Appendix 2 for sampling sheets).

10.1.3. Trouble-Shooting

Setting up the MOCNESS still takes awhile, and as we will be breaking down and setting up this system frequently over the next year there are a few improvements to the process that could be made. Specific notes from Taylor Crockford include:

- Tightening the rods **before** putting on the bracket with the cut out on.
- Keeping the special 'flat' washers on appropriate hardware so there is no confusion (they go on the top starboard side of the net.
- When attaching the bumpers, check that the LED bars fit before doing anything else.
- Leave bolts, etc. in their places when taking MOC apart
- Label the "top" of the cod ends container with net numbers
- Label the "outer" MOC net corners with "top left", "bottom left", etc. for re-attaching
- Consider taking off the outer net for wash-down.

Before the next cruise it would be wise to check O-ring size for the cans as there appeared to be some water between the O-rings of the strobe housing. Also, we need to replace the cod-end rubber bands, and be sure to have replacements. There appeared to be a tear in the screen of one of the cod ends (#8?). We need to be sure we pack a second funnel, as the wind almost took ours on day one, and splitting would have henceforth been problematic without a back-up. The ethanol containers need to be better positioned so that we can get to the spigots and we need a better storage system for the jars. Finally, the samples had a great deal of phytoplankton in them and by the time we got to replacing their ethanol on the evening of the 2nd day they were well past needing a change. Also of note, we ended up changing those jars multiple (x3?) times to remove excess pigment. We need to figure out whether we want to change the ethanol aboard ship (and thus bring along a waste container and lid sieve for replacing ethanol) or we could re-split them once we get to the lab by sieving and put the large fraction in a separate container.

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 station 1 on day 1 and station 2 on day 2.

10.2.2. Methods

The VPR was deployed off the aft via the same winch as the CTD and MOCNESS. The hard-drive was removed following each cast and the data downloaded. Quick visual scrutiny of the data in Autodeck was performed ship-board to look for any depths of high pteropod abundance; no such depths were evident in the VPR data based on this preliminary examination.

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)

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 bookclamp to attach the net was borrowed from Phil Alatalo. Ship speed during tows was ~1-1.5 knots. The downcast was done at ca. 5 m/min and the upcast at 5 m/min with a tow-yo pattern. The winch on the Tioga is currently not set to go at speeds lower than 5 m/min. We have some concern that this is too fast for the collection of the animals since some of the large individuals from Reeve 1 had shell damage. Ken said there are electrical and mechanical things that can be done to modify the winch speed. Alternatively we can send the net to a particular depth and leave it there.

In the wet lab, the cod end was promptly divided among a number of buckets and diluted with fresh filtered seawater. These buckets were individually poured into a white plastic tray for sorting. Since pteropods tend to sink, the bottom buckets were examined first. Individuals were transferred to plastic beakers at low densities (>20 individuals) for experimentation. Species identification was done using a dissecting microscope while individuals were still alive (Figure 9.5.1).

10.3.3. Preliminary Findings

The first Reeve net was aimed to avoid the phytoplankton layer (>25 m) and it returned without catching much of anything. There were a few very large pteropods in the net, but they were not all in perfect condition. The second Reeve net targeted the phytoplankton layer and it came back packed with phytoplankton, jellies as well as a fair number of pteropods. The cod end was completely full, and it took a while to get to the bottom, suggesting that it would be a good idea to have a second cod end available to

transfer the top portion of the catch into. Once we got to the bottom of the bucket we found a fair number of smallish adult pteropods (~150 individuals) that seemed to recover from their long stay in the cramped cod end once we put them into filtered water. Also in this haul were thousands of very small adults, juveniles and veligers (200-250 µm), some of which were kept for later study in both RNAlater and in a trash can. Throughout the cod end were hundreds of very small gymnosomes, likely *Clione limacina* as adults of this species were found in the MOCNESS.

11. Cruise Participants

Science Party

1	Zhaohui 'Aleck' Wang	Chief Scientist	WHOI	Chemistry
2	Gareth Lawson	Scientist	WHOI	Biology
3	Amy Maas	Postdoc	WHOI	Biology
4	Mike Lowe	Postdoc	WHOI	Biology
5	Katherine Hoering	Research Assistant	WHOI	Chemistry
6	Taylor Crawford	Research Assistant	WHOI	Biology
7	Camille Pagniello	Summer Student	WHOI	Biology/AOPE

Officers and Crew

1	Ken Houtler	Captain
2	Ian Hanley	Mate

12. References

Dickson AG (1981) An Exact Definition of Total Alkalinity and a Procedure for the Estimation of Alkalinity and Total Inorganic Carbon from Titration Data. Deep-Sea Research Part a-Oceanographic Research Papers 28: 609-623

Dickson AG, Sabine CL, Christian JR (2007) Guide to best practices for ocean CO_2 measurements. PICES Special Publication

Wang ZA, Wanninkhof R, Cai WJ, Byrne RH, Hu X, Peng TH, Huang WJ (2013) The marine inorganic carbon system along the Gulf of Mexico and Atlantic Coasts of the United States: Insights from a transregional coastal carbon study. Limnology and Oceanography 58: 325-342

Wang ZHA, Cai WJ (2004) Carbon dioxide degassing and inorganic carbon export from a marsh-dominated estuary (the Duplin River): A marsh CO_2 pump. Limnology and Oceanography 49: 341-354

Appendix 1: Event Log - TIOGA 668. NOTE: Many of the latitudes and longitudes recorded by hand appear to be erroneous. Corrected values (Corr.) are from the boat's along-track data.

				Local Time			Event	Latitude (°N)	Longitude (°W)	Corr. Lat. (°N)	Corr. Long. (°W)	Cast Depth	Water Depth	
event	**Instr**	**cast**	**St #**	**Mth**	**Day**	**hhmm**	**s/e**	**Deg. Min.**	**Deg. Min**			**(m)**	**(m)**	**Comments**
	Depart P-town			5	21	700								
1	CTD	1	1	5	21	1058	start	4237.4463	6919.1855	42.6353	-69.601	291	295	Down 45 m/min up 50 m/min
2	ctd	1	1	5	21	1123	end	42 37.4463	69 19.1855	42.6365	-69.6062			
3	ctd	2	1	5	21	1144	start	4237.4463	6918.5065	42.6372	-69.6101	175	298	
4	ctd	2	1	5	21	1207	end	4237.4463	6918.5065	42.6401	-69.6164			
5	vpr	1	1	5	21	1227	start	4237.4463	6918.5065	42.643	-69.6211	289	i	S1; strong angle 45 to left; releasing 290 m of wire
6	vpr	1	1			1246	end	42 37.496	69 18.506	42.6456	-69.6256			
7	mocness	1	1	5	21	1334	start	4238.1466	6913.9574	42.6135	-69.5748			failure early on in tow, bringing up, still preserving net 0, picked Pt. from jar 2
8	mocness	2	1	5	21	1440	start	4238.1466	6913.9574	42.6299	-69.5976			LED OFF
	Return P-town			5	21		end							
	Depart P-town			5	22		start							
9	ctd	3	2	5	22		start	4219.3395	6920.1684			255	259.5	
10	ctd	3	2	5	22	1001	end	4219.3395	6920.1684	42.3343	-69.7855			
11	vpr	2	2	5	22	1013	start	4219.3395	6920.1684	42.3342	-69.7866	255	258.5	S1; 30 m/min; 255 m of wire
12	vpr	2	2	5	22	1033	end	4219.3395	6920.1684	42.3337	-69.7873			
13	mocness	3	2	5	22	1104	start	4219.3395	6920.1684	42.3319	-69.788	255	262	
14	mocness	3	2	5	22	1223	end	4219.3395	6920.1684	42.3674	-69.7894			

15	reeve	1	2	5	22	1318	start	42 19.335	69 20.1684	42.3159	-69.8498	30 mwo		6 m/min in/out
16	reeve	1	2	t	22		end							
17	reeve	2	3	5	22	1431	start	4220.4877	6940.089	42.2326	-69.9867			
18	reeve	2	3	5	22	1448	end	4220.4877	6940.089	42.2281	-69.9916			end flowcount 161823
19	ctd	4	4	5	22	1509	start	4212.0534	70021.0957	42.2007	-70.0349		136	
20	ctd	4	4	5	22	1528	end	4212.0534	70021.0957	42.1986	-70.0356			
	Return P-town			5	22		end							

MOCNESS DATA SHEET

Cruise T1668 Location Wilkinson Basin Stn 1 Tow # M-25-001

Date May 21 2013 Wind Speed 10-12kt Direction SE

Year/Day _____ Sea State 3-5 ft

Local Time 1340 to 1410 Start Lat 42 36.949 Long 69 34.7587

GMT Time _____ to _____ End Lat _____ Long _____

Net Size 1/4 m² Net Condition fair

Net Mesh 150 µm

Processed Filename T1668M1.prd Raw Filename T1668M1.DAT

Time 5 min fast.

NET TOW INFORMATION

	Time Open	Depth (m)	Angle	Flow Counts	Volume Filtered	MWO Net	Comments
Start							started at 60 m/min
Net 0	1340	0					1343 ↑ to 20 m/min
Down							
Net 1							170m couldn't connect to U/W unit. Restarted ok.
Net 2							
Net 3							1359 ↑ to 25 m/min
Net 4							
Net 5	1400	192m					couldn't connect to U/W unit. Then can't connect to stroke.
Net 6							
Net 7							
Net 8							On deck - communicated fine. D.O.U flds.
Closed							

COMMENTS: _____

MOCNESS DATA SHEET

Cruise T1668 Location Wilkinson Stn 1 Tow # M-25-002

Date May 21 2013 Wind Speed 10-12 kt Direction SE

Year/Day _____ Sea State 3-5'

Local Time 1448 to _____ Start Lat 42 37.218 Long 69 36.032

GMT Time _____ to _____ End Lat _____ Long _____

Net Size 1/4 m² Net Condition Fair

Net Mesh 150 µm

Processed Filename T1668M2.pm Raw Filename T1668M2.raw

Clock 5 min fast relative to ship.

NET TOW INFORMATION

	Time Open	Depth (m)	Angle	Flow Counts	Volume Filtered	MWO Net	Comments
Start	1448	0					Down at 10 m/min
Net 0 Down	1512	283.5					1449 ↑ to 20 m/min.
Net 1	1512	283.5		In at 10 m/min			1458 ↑ to 25 m/min
Net 2	1520	260			143.6 m³		1500 ↑ to 30 m/min
Net 3	1524	227	→ Dipped to 230. Had to maintain speed.				
Net 4	1537	151	↓		244 m³		
Net 5	1548	100	Dipped to 152				Angle not great
Net 6	1556	74					In at 5 m/min too Cow.
Net 7	1559	52					
Net 8	1606	23					
Closed	1613	0					

COMMENTS: Dummied w/ Stube

July 24

MOCNESS DATA SHEET

Cruise T1668 Location Murray Basin stn 2 Tow # M-25-003

Date May 22 2013 Wind Speed 5-10 kt Direction SW

Year/Day _____ Sea State 2-4'

Local Time 1110 to _____ Start Lat 42 19.4 Long _____

GMT Time _____ to _____ End Lat 6947 Long _____

Net Size 1/4 m^2 Net Condition fair

Net Mesh 150 µm

Processed Filename T1668M3.prd Raw Filename T1668M3.raw

laptop clock 5 min faster than ship's clock

270.250

270.230

NET TOW INFORMATION

May 476

	Time Open	Depth (m)	Angle	Flow Counts	Volume Filtered	MWO Net	Comments
Start	1110	0					slowed down at 10 m/min
Net 0 Down	1134	255					1117 ↑ to 20 m/min 1120 ↑ to 25 m/min
Net 1	1139	230					
Net 2	1145	200					→ Dipped to 203 w/ ship slowed
Net 3	1154	149					→ Dipped to 153
Net 4	1204	95					
Net 5	1209	74					
Net 6	1215	50					
Net 7	1220	25					
Net 8	1225	0					
Closed							

COMMENTS: Water depth 258 at start NO shoso

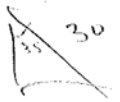
Reeve Net Samples

T1088.08

Cruise: NH1208	Station: 3	Cast #: 1
Date: 5/22/	Latitude: 42 19.3395	Longitude: 69 20.1684
Local time start: 13:18	120935	Local time end:
Wire speed out: 6 m	145910	Wire speed in:
Angle out: 35°		Angle in:
Wire out (m) 30		

Cast comments:

Taxonomic notes:



$\cos 35 = \frac{A}{30}$

24.57

up to 10 mm D

few large L. retroversa

very little of anything except copepods

TI 688-03

Reeve Net Samples

Cruise: NH1208	Station: 3	Cast #: 2
Date: May 22	Latitude: 42, 20.487	Longitude: 69 40.889
Local time start: 14:31	14591D	Local time end:
Wire speed out:	60m	Wire speed in: 60m
Angle out:	20° ish	Angle in:
Wire out (m)		

Cast comments:

Taxonomic notes:

thousands of juvenile Clione ?? limacina ?? (DARK color)
~150 small adult L. retroversa
Billions of juvenile/veliger L. retroversa

Tons of mnemiopsis ctenophores, some jellies. PACKED with phytoplankton