Chief Scientist: Al Plueddemann,
Cruise Dates: May 12 – June 2, 2016

R/V *Neil Armstrong* & R/V *Sally Ride* Debrief Questions
UNOLS Fleet Improvement Committee 2016

Dear Chief Scientist,

The UNOLS Fleet Improvement Committee requests that you provide feedback on your recent cruise on the Ocean Class *R/V Neil Armstrong*. The purpose of these questions is to help determine how key underlined design and outfitting features of the vessel have either benefited or hindered your cruise objectives. The FIC will use your feedback to inform design recommendations for future Ocean Class and other Research Vessels. A member of FIC will contact you by phone shortly after your cruise to get your responses.

Jim Swift
FIC, Chair
Email: jswift@ucsd.edu

1. Size: The *Armstrong has* a LOA of 238 ft, a beam at midship of 50 ft, and has berths for 24 scientists. Science labs occupy 2,035 sq ft including 1,023 for the main lab, 398 for the wet lab, 311 for the computer lab and 303 sq ft in the staging bay. The aft working deck area is 2,557 sq ft.

Has the overall size of the vessel either enabled or hindered you in meeting the science objectives of your cruise? Is there sufficient lab space of the appropriate type? Are there sufficient berths available to accommodate an optimal science party? Were the living arrangements satisfactory? Please explain using specific examples that relate to your science objectives.

The answer really depends on how expectations are set. I have done multiple cruises on Oceanus and Knorr. On the one hand, Armstrong is a spectacular replacement for Oceanus – no complaints, end of story. On the other hand, there are limitations on meeting science objectives on Armstrong vs. the Knorr. Since there is not much to say about the first perspective except that I am thankful for access to such a great ship, I will focus (here and below) on limitations as seen from the second perspective.

There are not enough science bunks for a large program, multi-institution, interdisciplinary process cruise. The community baseline is set for ~30 scientists, Armstrong comes up short at 24. There is insufficient lab space. The Global class vessels have 1800 sq ft of re-configurable space in the main lab alone, Armstrong comes up short with ~1000 sq ft, narrow benches and too many built-in cabinets that just create dead space. There is not enough fore/aft working deck on the fantail. Mooring deployment schemes have to be modified and are made less efficient by the short distance from the transom and A-frame to the working area of the deck. Vans cannot be accommodated without sacrificing crucial deck space. Global class vessels can hold vans on the 01 deck and the bow, whereas on the Armstrong they take up the only large area of fore-aft working space on the main deck. The CTD hangar/wet lab space is sub-optimal. The Knorr has a CTD hangar completely out of the weather and a sizable analytical lab that can be closed and temperature controlled, whereas the Armstrong CTD is exposed to the weather and can't be moved to the hangar, and the Armstrong analytical lab can't be sealed from the outside and doesn't make sense as a place to draw water from the rosette.

2. Performance: The endurance of the *R/V Armstrong* is 40 days with an expected range of 10,000 nm at 12 knots. The vessel has a design cruising speed in calm open water of 12 kts.

Have any of these performance capabilities of the vessel either enabled or hindered you in meeting the science objectives of your cruise? Please explain using specific examples.

Endurance and cruising speed are fine from my perspective. I am worried about what I saw in terms of roll response. The roll was not terrible, but it was what I would expect in, say, 12 ft seas. The actual swells were only about 6 ft. Will larger sea states result in un-workable conditions so that science has to shut down when the swell comes up? I don't know the answer, but I fear that the roll response will result in weather limits much more restrictive than anticipated.

3. Over-the-Side Handling Systems: The *R/V Armstrong* has been outfitted with a system that allows "hands free" launch and recovery of CTD using an over boarding device with docking head and motion controlled winch systems. It also has:

- 30,000 lb SWL Stern A-Frame with maintenance position near the main deck.
  The A-frame is a nice design. The extended width allows "big stuff" to pass through, and just as importantly, can be set up with multiple blocks for complex lifts and multiple winches/tuggers etc. A winch on the top of the A-frame would be a great addition.
- 70 foot radius Knuckle, Extension Boom Crane with 10,000 lb SWL at sea fully extended.
  Great to have a big crane that can reach most (all?) of the aft working area of the ship. But it comes at a cost: 1) Visibility is not good for the operator to many areas of the deck. 2) Big cranes with long extension are slow and awkward for "delicate" lifts. Based on what I saw on an early cruise, crane limitations look like science limitations to me. We are expecting to need to bring our own deck-mount knuckle crane for handling ROVs and AUVs, for example.
- Two Hydro Winches with 322 EM Cable (Motion Compensated) and 3/8 inch wire rope.
  Great, no complaints from my perspective.
- Traction Winch with two tension member drums (.681 EM Cable and 9/16 3X19 Wire Rope)
  No opportunity to use it yet, but specs seem good.
- Portable crane with one location forward and two locations on the aft working deck.
  I must have missed something, but I don't remember a portable crane. There was a small crane forward used for loading stores. Is this relocatable to the aft working deck for science use?

Did these systems have a positive impact on your work and if so how? Are there any negative impacts associated with these systems?

4. Hull Mounted Sonar Suite: The ships sonar flat is outfitted with:
- Kongsberg Ksync - Sonar Synchronizing system
- Kongsberg EM122 1x2 - Multibeam
- Kongsberg EM710 .5X1 - Multibeam
- Kongsberg EK80 (18, 38,120, 200, and 333 kHz) - Split Beam Sonar
- Knudsen 3260 12 kHz - Chirp PDR and 3.5 kHz Sub Bottom Profiler
- Teledyne RDI OS 38 kHz - Acoustic Doppler Current Profiler (UHDAS)
- Teledyne RDI OS 150 kHz - Acoustic Doppler Current Profiler (UHDAS)
- Teledyne RDI WM 300 kHz - Acoustic Doppler Current Profiler (UHDAS)
- Kongsberg HiPAP hull unit and gantry with SONARDYNE Ranger 2 USBL
- Kongsberg SSVS and temperature sensor system
- Mantech SONAR Self Noise and video Monitoring Array
- Doppler Speed Log

Which of these systems were essential to science objectives during your cruise? What is the quality of the data collected?

The hull mounted sonar suite is fantastic. My compliments to those who spec'd this and pushed it through as part of the standard equipment. I think we used 10 of these 12 systems on my first cruise. Yes, there is interference, so you can't have everything at once. But these are excellent tools for science and I am grateful for the well-outfitted sensor suite.

5. Spare Transducer Wells and Aft Transducer Tube: The *R/V Armstrong* has three spare transducer wells installed in the transducer room as well as a Transducer tube with access from the Aft Main Deck for installation of temporary acoustic systems and other instrumentation.

Did you use any of these spare transducer locations to install instrumentation specific to your project and did they support your requirements?

I am actually unsure of whether we used them or not, because engineers associated with another project did the transponder set up. Nevertheless, I think having this capability is a positive for science users.

6. Acoustically Quiet: The *R/V Armstrong* was designed, engineered and built to meet a modified radiated noise curve that is not as stringent as the ICES 209 requirement. Radiated airborne noise within the ship is also designed to be at low levels.

Have you noticed any difference compared to other vessels, and has this had any positive or negative impacts on your work?

Yes, a positive impact. It is quiet and we noticed the difference in communication with our acoustic releases. (There are some nasty airborne noises at some locations on the working deck, however).

7. Vans and deck space: The van set up of the *R/V Armstrong* for any particular cruise is "modular" in that there is a choice between more deck space or more enclosed lab or

storage space. The design of the *R/V Armstrong* incorporates the ability to fit two 20 ft ISO Containers vans on the aft deck for lab space or other uses and a third 20 ft van stacked on top of the inboard van with access from the Focsle Deck. These vans are mounted to dedicated deck fittings, and provided with services such as power, water, comms, drains etc.

If you have used the vans, how well did they accommodate your space requirements? Did this modularity have a positive or negative impact on your cruise planning and work at sea?

It is great to have space for the 20' vans, but I don't like the trade off of losing space on the main deck (see my comments under #1). (Yes, it is better than not having the choice at all). We were unable to manage a 3rd van stacked on the inboard van for our cruise, but I think this problem can be solved.

8. Dynamic Positioning: The *R/V Armstrong* was designed and outfitted with dynamic positioning (DP) capabilities. This is accomplished by using two controllable pitch propellers, two large independently controlled fast acting rudders, a stern tunnel thruster, a trainable bow thruster and a commercially available computer controlled precision navigation system. All of these components add cost, maintenance requirements and complexity to the operation of the vessel.

How important was the DP system to your work? How well did this system operate during your cruise(s)?

Extremely important – mission critical. And it worked very well. It will only get better as the bridge crew learn the nuances. No complaints. We need this capability, despite up-front cost, maintenance and complexity.

9. Lab Arrangement: The *R/V Armstrong* labs were pre-outfitted with lab benches and science services (air, electricity, water, seawater, etc).

Did you find the existing arrangement easy to modify and was the quantity of service outlets for air and water adequate, too many or too few?

I don't like the "pre-outfitted" nature of the labs. Please take all the benches and cabinets out. Give me an open floor plan with a "grid" of tie-down points on the floor and a few bolt-down benches of various sizes with open space underneath them. Like the Korr! Like the Ron Brown! My comment after seeing a very modest number of people (about 10) completely fill the main lab was "this lab packs small". Usable space is not accessible due to the built-in cabinets and the configuration is not flexible due to the "pre-configured" style. The good news is that this is easily fixable at modest cost.

10. Marine Mammal Observation Area: The *R/V Armstrong* has an area for observers to sit and stand forward of the pilothouse on the 0-1 deck. There is a table and connections to the ship's network and locations for mounting "Big Eye" binoculars.

Did you use this area and if so, did you find this area adequate for science observations? If not, what changes would help make it more useful?

No comments. We don't have a need for this space. The table was nice for watching the sunset.

11. Internet access and bandwidth**: Did you plan telepresence activities and were facilities satisfactory? Did you have high speed internet or special bandwidth requirements for science? Was the internet connectivity adequate for other broader impact, science or normal communication activities?**

It was not so good on our trip, but I believe this was due to some "teething pains" on the early cruises. You would need to ask others (e.g. Tim Shank, Ken Kostel) to get a more informed opinion.

12. Other Features: **Can you describe other design, outfitting or operational features of the *R/V Armstrong* that had significant positive or negative impacts on your work at sea? Should these features be requirements of other new UNOLS Research Vessels? Were there any important design features missing which would benefit a wide variety of projects?**

I am sympathetic to the various accommodations for handicap access. However, we might expect these to be exercised only occasionally. Couldn't we make the base configuration suitable for normal work (e.g. with water-tight boundaries from deck to lab and lab to lab) with removable hatch panels that would accommodate handicap access? Making the base configuration handicap accessible, with no water boundaries on the floor from weather deck to inner labs, results in a very wet ship.

Armstrong SVC-5 Report

Rob. L. Evans, Dan Fornari, Dan Lizarralde.

This short 4 day cruise was focused on geophysical activities across the shelf, south of Martha's Vineyard. WHOI vessels have, traditionally, not carried out a large amount of geophysical work, and so this cruise offered an opportunity to expose the crew to this kind of activity on a new vessel.

The primary science objectives included:

1. Deployment and recovery of a large ocean bottom seismometer in 80m of water, using a heave compensating winch.
2. Recovery of seafloor magnetotelluric (MT) instruments deployed in September 2015 off the shelf-edge.
3. Acquisition of towed magnetics data along a profile to subsequently be followed by a wave-glider deployed from the ship.
4. Acquisition of multi-channel seismic data generated by a sparker source along profiles across and along the shelf edge. This work is focused on looking at gas and fluid emissions from the seafloor along the shelf edge.
5. Acquisition of video and still camera images across seep features of interest using the WHOI MISO-TowCam system.

Ship Operations and Equipment

It is already well established that the vessel has a wet starboard and back deck in transit conditions where there is a moderate sea-state. The same was true on our transit out and some of that water found its way into the wet and main labs. Even far forward reaches of the main-lab floor were wet. This problem is known, but I'll reiterate that this needs addressing urgently. Water on the floor of the main lab is a potential safety issue. Some of the outer deck areas also become slippery and need application of non-skid. Some equipment (lithium batteries for example) could become damaged or dangerous if exposed to seawater.

Deck space on the starboard side is somewhat limited. We were able to deploy and recover equipment from this side using the CTD and aft boom cranes. However, I can envision equipment for which deployment would either have to be through the A-frame or involve the main ship's crane, with assembly carried out on the port side. There is, at present, no video-feed or visual connection between the port-side and the bridge. Recoveries have to be done on the starboard side and, for some instruments, would need to involve the main crane. That seems sub-optimal, but there is little that can be done to change the starboard side configuration.

There is an air vent coming from the engine room right outside the door to the main deck starboard side that issues diesel fumes to that area, which is also under an overhang so the fumes stay there, and when the door opens that gets into the ship. In addition, numerous times crew members smoke there because it is a space under cover – the area by the door should be marked as NO SMOKING.

The crew is obviously new to the ship, and some are new to WHOI, and they are still familiarizing themselves with driving the various cranes, and A-frame. They had opportunity to carry out several instrument recoveries using the starboard side equipment.

The new CTD crane/boom system worked well, but the rate of pickup (both from the deck and from the sea surface) should be increased if possible, it is slow and especially on recovery should be faster at being able to reel up the package into the boom end ring once lifted out of the water.

We used DP while running TowCam operations and this worked well.

There is a davit on starboard side level above the main deck that seems useless and which blocks passage along the main walkway. We suggest moving the davit or removing it as it is unclear what purpose it serves.

Internet

For the most part, the internet connectivity seemed ok. I certainly didn't hear any complaints. There are courses directions for which satellite connection is poor, but this is known.

Lab setup

A geophysical cruise has demands for lab setup that are quite a bit different from most other cruises. Our work is, by nature, more computer oriented, and so for us, a separation of the main lab and the computer lab is awkward as it places watchstanding needs in two places.

We recommend rethinking the layout at the forward end of the main lab and computer lab. We suggest removing the wall currently in place between these two rooms and moving it forward to make a smaller closed air-conditioned space for servers. This would allow for a large display area at this end of the main lab with well configured data displays. The visual displays in the main lab that do exist at present could be better configured and, as configured seem a little ad-hoc, with some key information missing. We found it strange that there is no display in either main or computer lab of the ship's position or information on ETA to waypoints. Also, the current door layout between main and computer labs is awkward as currently configured and this would offer a solution.

The R/V Lansgeth is perhaps the type example of a well setup main lab for geophysics purposes. There, they have a large glass topped table with a flat screen monitor mounted beneath that can be used to display track lines and ship location. This, with map overlays, becomes a focal point for activities in the lab. Once NavEST or equivalent is installed on board the vessel, it would allow map overlays for USBL operations.

The keys on cabinets in the main lab seem destined to have a short life-span. Can something better and more durable be installed? The cabinet above the printer is in a dangerous position in heavy seas.

Science Equipment

EK80 worked well. This is a nice tool and will be a valuable addition to the data routinely collected. I would encourage SSSG to turn this on automatically unless it provides a conflict with the other science operations taking place.

Multibeam worked well.

XBTs were not working. The XBT patch panel should be in the main lab (it is currently outside).

USBL was used for TowCam operations. This worked well with the Sonardyne software, but NavEST or an equivalent display/recording system needs to be installed (as it is on Atlantis) to allow USBL beacon positions to be displayed with map underlays on the computer screen and for the USBL navigation data to be recorded and properly date/time stamped with UTC and in lat/long coordinates.

We only used the 3.5kHz Knudsen for a short period of time. It is not setup/functioning properly (although it has worked on previous legs) and it is also extremely noisy on the main deck when it is in operation. The transmit seems to be working properly and it is possible to cycle through different pulse lengths and power levels. There is, however, an inability to detect the bottom bounce and this needs troubleshooting.

The Nav screen from the bridge is not at present routed to the labs or other spaces where it might be needed. It is essential that this be remedied and made available to all labs or where needed.

The CTD winch read out in the main lab is incorrect. Also, some of the met sensors were not operational.

Accommodations and Livability

We had a full complement of scientists and all bunks were taken.

The chief scientist's cabin is small. It would be nice to have a display in the room of ship's position, ETA etc. Since this cabin doesn't really rise to the status of a normal chief-scientist cabin, perhaps this, and one other cabin that is a single, could have fold-down bunks to raise the size of the science party?

The layout of food service in the galley is awkward –it is highly unusual for the science party to enter the galley to get food and there are no guards/screens above the food. Some commented on the layout of the fridge, microwave and toaster as awkward. It seems like another small table (4 seater) could be added at the forward end of the mess room.

There is currently no exercise room on board ship.

A method to secure privacy screens on bunks would be helpful as they slide in rough seas. Also, a small shelf above the bunk would be nice. Additional clothes hooks and towel hangers would be helpful.

The water on the ship tastes 'funny'. Does the ship have a R-O system like Atlantis? If not it is likely that will need to be installed ASAP so that the drinking water is more palatable.

General Safety Issues and Suggestions

- Water in dry lab is a safety issue both as a slip hazard and from a potential damage to equipment (e.g. Lithium batteries are often used for equipment).
- Make safety video available online before cruise (I still find it remarkable that UNOLS does not require completion of an offshore safety training course prior to sailing).
- Add hangars for foul weather gear in the wet-lab or hangar.
- There should be harassment forms in the heads on board.

- The life jackets are the type that are likely to be dangerous if not held properly on entry into the water. WHOI should invest in much better life jackets.
- There should be a hard had and work vest storage area/rack for science use, and a selection of general use steel-toed boots for scientists to wear if they did not bring any.

Chief Scientist: Gareth Lawson
Cruise Dates: June 17-23, 2016

R/V *Neil Armstrong* & R/V *Sally Ride* Debrief Questions
UNOLS Fleet Improvement Committee 2016

Dear Chief Scientist,

The UNOLS Fleet Improvement Committee requests that you provide feedback on your recent cruise on the Ocean Class *R/V Neil Armstrong*. The purpose of these questions is to help determine how key underlined design and outfitting features of the vessel have either benefited or hindered your cruise objectives. The FIC will use your feedback to inform design recommendations for future Ocean Class and other Research Vessels. A member of FIC will contact you by phone shortly after your cruise to get your responses.

Jim Swift
FIC, Chair
Email: jswift@ucsd.edu

The chief scientist on the AR06, June 17-23, 2016 cruise was **Gareth Lawson**. He provided a very detailed report on the ship facilities and capabilities, including some SOPs for the mid-water trawling. I (Nancy Rabalais, **NR**) was able to interview him on October 6. There was not much more to add to his report, but we went through the questions anyway.

1. Size: The *Armstrong has* a LOA of 238 ft, a beam at midship of 50 ft, and has berths for 24 scientists. Science labs occupy 2,035 sq ft including 1,023 for the main lab, 398 for the wet lab, 311 for the computer lab and 303 sq ft in the staging bay. The aft working deck area is 2,557 sq ft.

Has the overall size of the vessel either enabled or hindered you in meeting the science objectives of your cruise? Is there sufficient lab space of the appropriate type? Are there sufficient berths available to accommodate an optimal science party? Were the living arrangements satisfactory? Please explain using specific examples that relate to your science objectives.

Gareth: The lab size was good and sufficient for their work. They could have added more science to the space if they had wanted, but there are bunk limitations. The fixed locations were okay, but they are used to being able to be modular. They filled all bunks, 22 + 2 techs. Living arrangements were good; the food was good; overall a very enjoyable cruise. **NR** asked about the lack of a single Chief Scientist bunk, just out of curiosity. That was not an issue to **Gareth**. We did discuss the sometimes irregular hours for the Chief Scientist as issues come up.

2. Performance: The endurance of the *R/V Armstrong* is 40 days with an expected range of 10,000 nm at 12 knots. The vessel has a design cruising speed in calm open water of 12 kts.

Have any of these performance capabilities of the vessel either enabled or hindered you in meeting the science objectives of your cruise? Please explain using specific examples.

NR: we discussed speed, with regard to some of the sonar suite instruments (see below)

3. Over-the-Side Handling Systems: The *R/V Armstrong* has been outfitted with a system that allows "hands free" launch and recovery of CTD using an over boarding device with docking head and motion controlled winch systems.
Gareth: The automated launch and recovery system for the CTD is limited by the height of the CTD package. No room for more on top or bottom. The functionality of the methods is good, but they had to adapt in some cases. Their cruise was calm and the chemists were able to work the CTD unit for water collections as they steamed to the next station. Could see where inclement weather would necessitate some sort of closed area. We discussed the use of a temporary curtain, a track system to move it forward under the overhang, but he did not know if there was enough height, a track system to the bay, but the bay is also much more important for other reasons, i.e., place to work on AUVs, moorings, storage until deployed, retrieved.

It also has:

- 30,000 lb SWL Stern A-Frame with maintenance position near the main deck.

Gareth: Fantastic for all that they put over, including large MOCNESS and a smaller mid-water trawl. There is not an absolute clear line of site for the operator.

- 70 foot radius Knuckle, Extension Boom Crane with 10,000 lb SWL at sea fully extended.

Gareth: crane operators were always skilled and adept with the equipment, including the portable crane.

- Two Hydro Winches with 322 EM Cable (Motion Compensated) and 3/8 inch wire rope.
- Traction Winch with two tension member drums (.681 EM Cable and 9/16 3X19 Wire Rope)

Gareth: believed that they may have been the first to use the traction winch with the .681 EM cable for the EK80, which he understands might be only the second in the oceanographic fleet globally. Worked very well.

- Portable crane with one location forward and two locations on the aft working deck.
  Did these systems have a positive impact on your work and if so how? Are there any negative impacts associated with these systems?

Gareth: There is no suitable way to tow something over the side starboard. Can't use any of the existing launch and recovery capabilities, including a crane. The maximum angle for the wire was not supportive of, for example a 1-m ring net. Even drifting, was not suitable.

4. Hull Mounted Sonar Suite: The ships sonar flat is outfitted with:

- Kongsberg Ksync - Sonar Synchronizing system
- Kongsberg EM122 1x2 - Multibeam
- Kongsberg EM710 .5X1 - Multibeam
- Kongsberg EK80 (18, 38,120, 200, and 333 kHz) - Split Beam Sonar
- Knudsen 3260 12 kHz - Chirp PDR and 3.5 kHz Sub Bottom Profiler

- Teledyne RDI OS 38 kHz - Acoustic Doppler Current Profiler (UHDAS)
  Gareth: this one was broken
- Teledyne RDI OS 150 kHz - Acoustic Doppler Current Profiler (UHDAS)
- Teledyne RDI WM 300 kHz - Acoustic Doppler Current Profiler (UHDAS)
- Kongsberg HiPAP hull unit and gantry with SONARDYNE Ranger 2 USBL
- Kongsberg SSVS and temperature sensor system
- Mantech SONAR Self Noise and video Monitoring Array
- Doppler Speed Log

  Which of these systems were essential to science objectives during your cruise? What is the quality of the data collected?

Gareth: We were able to synchronize the Ksync with the Kongsberg EM710, with the Kongsberg EK80, and the RDI OS 150 Hz, used by the physical oceanographer on the cruise. But, synchronization did not work in some of the configurations that they tried..

5. <u>Spare Transducer Wells and Aft Transducer Tube</u>: The *R/V Armstrong* has three spare transducer wells installed in the transducer room as well as a Transducer tube with access from the Aft Main Deck for installation of temporary acoustic systems and other instrumentation.

Did you use any of these spare transducer locations to install instrumentation specific to your project and did they support your requirements?

Gareth: did not use.

6. <u>Acoustically Quiet</u>: The *R/V Armstrong* was designed, engineered and built to meet a modified radiated noise curve that is not as stringent as the ICES 209 requirement. Radiated airborne noise within the ship is also designed to be at low levels.

Have you noticed any difference compared to other vessels, and has this had any positive or negative impacts on your work?

Gareth: Back deck is loud, and one of the scientists on board had a phone app that indicated the limit was exceeded.
They tried variable ship speeds while towing the EK80, up to 7-8 kn, when data quality and drop outs were experienced. Due to the noise of the vessel, they weren't able to go faster than 7-8 kn without compromising data quality at the higher frequency channels on the EK80. The drop out issue, and not being able to e.g. see if schools, had to do with sea state -- initially when things were flat calm the data were fine but then as it got just a little rougher we started getting drop outs.

7. <u>Vans and deck space</u>: The van set up of the *R/V Armstrong* for any particular cruise is “modular” in that there is a choice between more deck space or more enclosed lab or storage space. The design of the *R/V Armstrong* incorporates the ability to fit two 20 ft ISO Containers vans on the aft deck for lab space or other uses and a third 20 ft van stacked on top of the inboard van with access from the Focsle Deck. These vans are mounted to dedicated deck fittings, and provided with services such as power, water, comms, drains etc.

If you have used the vans, how well did they accommodate your space requirements? Did this modularity have a positive or negative impact on your cruise planning and work at sea?

Gareth: Did not use vans, but could see how the back deck could be squeezed with them on board.

8. Dynamic Positioning: The *R/V Armstrong* was designed and outfitted with dynamic positioning (DP) capabilities. This is accomplished by using two controllable pitch propellers, two large independently controlled fast acting rudders, a stern tunnel thruster, a trainable bow thruster and a commercially available computer controlled precision navigation system. All of these components add cost, maintenance requirements and complexity to the operation of the vessel.

How important was the DP system to your work? How well did this system operate during your cruise(s)?

Gareth: Did not need it. When it was on, there were more dropouts on the EK80. The automated course adaptation feature could be seen to generate bursts of bubbles on EK80.

9. Lab Arrangement: The *R/V Armstrong* labs were pre-outfitted with lab benches and science services (air, electricity, water, seawater, etc).

Did you find the existing arrangement easy to modify and was the quantity of service outlets for air and water adequate, too many or too few?

Gareth: Very happy with the size and capabilities. The fixed locations were frustrating, when used to using more flexible spaces. There is no way to talk easily to the computer people, and it is necessary. There were monitors in the main lab, which helped. Two doors from the main lab open into a hallway, and could just be removed. Then a door to the galley could be installed.

10. Marine Mammal Observation Area: The *R/V Armstrong* has an area for observers to sit and stand forward of the pilothouse on the 0-1 deck. There is a table and connections to the ship's network and locations for mounting "Big Eye" binoculars.

Did you use this area and if so, did you find this area adequate for science observations? If not, what changes would help make it more useful?

Gareth: one of the scientists tested the observation area on the 0-1 deck. Very functional, but there was no way to see aft. The angle of sight was about 270 degrees. There was also no easy way to get aft or into the wheelhouse for full 360 degrees. No direct path. This is pretty important if you see something that you are passing and need to verify by getting to the back of the ship. Flying bridge would be better, but there are safety issues with the radars.

NR: I asked about clean air collections. **Gareth**: the jack staff (?) is suitable for this, but the scientist on board was not able to pull air for CO2 analyses because his pumps were too far away.

11. Internet access and bandwidth**: Did you plan telepresence activities and were facilities satisfactory? Did you have high speed internet or special bandwidth requirements for science? Was the internet connectivity adequate for other broader impact, science or normal communication activities?**

Gareth: The usual and many complaints about connectivity and band width. Giving priority to download of SST images worked, but mostly was not sufficient for the science group on board.

12. Other Features: **Can you describe other design, outfitting or operational features of the *R/V Armstrong* that had significant positive or negative impacts on your work**

at sea? Should these features be requirements of other new UNOLS Research Vessels? Were there any important design features missing which would benefit a wide variety of projects?
Gareth: great accommodations, good food, fun cruise, and just came out of a data meeting so can say that the data collected were also good.

NR: discussed another issue in a separate report about ADA heights on doors and showers. **Gareth**: there should be a higher lip on all showers, too much water getting out on the floor. Although the water tight doors for in and out of ship were designed with ADA in mind, it would be better to have a system suggested in another post cruise report with a removable hatch panel to be used at all times, except when the lower height was needed for ADA access. Wetness is a safety hazard.

R/V *Neil Armstrong*

Science Verification Cruise VI
REPORT - Evaluation of Ship Facilities and Capabilities

Cruise No. AR06, June 17 – 23, 2016

Report prepared by Gareth Lawson based on contributions from Carin Ashjian, Phil Alatalo, Dezhang Chu, Tim Duda, Jen Gatzke, Glen Gawarkiewicz, Chrissy Hernandez, Elise Hugus, Mike Jech, Jennifer Johnson, Andone Lavery, Joel Llopiz, Serdar Sakinan, Dan Torres, Aleck Wang, Peter Wiebe, and Gordon Zhang

Photograph: Carin Ashjian

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SUMMARY ASSESSMENT AND RECOMMENDATIONS

Overall, the Science Verification Cruise VI science party was very pleased with the *Armstrong*'s capabilities and were unanimous in their praise for the bridge and crew. Safety was a clear priority, and living conditions and food were very well received. Our science party was made up of physical, chemical, and biological oceanographers, together with acousticians and fisheries scientists. The ship is well equipped in terms of the necessary deck, laboratory, and storage facilities for our inter-disciplinary research needs. The Armstrong also boasts an advanced suite of instrumentation, particularly acoustic systems and notably the Simrad EK80 broadband echosounder, which make it very appealing for our work. Application of acoustics to biological studies is a specialty of our group, and a large number of acousticians and bio-acousticians participated in the cruise, such that evaluating the acoustic systems was a particular focus.

The science party did identify a number of concerns and areas for improvement pertaining to the vessel and its performance, and provided a series of comments and recommendations. This report first provides a general assessment of ship capabilities and performance and then evaluates the vessel with respect to specific science activities and groups. Overall these suggestions are offered here in the spirit of constructive criticism and we recognize that many of these are known issues and are likely already being addressed. A summary of the main findings, comments, and recommendations follows.

General

- Aspects of the layout of the laboratories could be improved; in particular, communication between the main and computer labs is difficult and would be improved by having a single large lab. This was especially a problem in coordinating acoustic data collection (EK80, multi-beam) with other operations. Reconfigurable benches would also be preferable to the current fixed layout.
- Storage in the labs could be improved (e.g., better latches on cabinets, fewer sharp edges, hooks/racks for hanging foul weather gear).

IT/Communications

- Although we were able to meet our few needs (downloading SST imagery and posting occasional photos to a cruise blog), off-vessel connectivity was very slow.
- Data storage and access was somewhat confusing to the science party and should be improved. The EK80 was used nearly continuously during the cruise; data couldn't be accessed in real-time and despite the relatively short cruise length, the large file sizes and overall volumes of data were overwhelming to the storage capacity.
- Real-time display of data such as ship's track, SOG, COG, time to next waypoint, water depth, and winch payout/tension, were not available at the time of our cruise but are key needs for decision-making.

CTD

- The automated Launch And Recovery System improves safety but limits the height of the CTD rosette and required a re-design of the deployment strategy for the NSF shared-use Digital Auto Video Plankton Recorder system. This arrangement worked well for the present cruise but the height issue could be a limitation for other instruments.

- Some form of shelter for the CTD is needed to allow water to be drawn, attending to attached instrumentation, etc.

Nets

- A variety of nets, including two large systems (a 10-m^2 MOCNESS and a midwater trawl) were successfully deployed, thanks to the large A-frame, large back deck, and trawl winch.
- Developing an additional capability to tow instruments over the side is crucial, however, to allow efficient transition between operations that have to be done over the stern (e.g., large nets) with smaller towed instruments (e.g. the 1-m^2 MOCNESS or ring net employed during the present cruise) and to reduce the impact of ship's heave and prop wash on smaller and lighter packages.
- Although the *Armstrong* is not designed to tow fish trawls, as it lacks port and starboard trawl winches, a constant tension winch, a trawl ramp, trawl monitoring systems, etc., a series of protocols were developed allowing a ca. 8x6m midwater trawl (with two 820lb doors) to be successfully deployed and retrieved.

Acoustic Systems

- The EK80 system allowed interesting observations of a variety of different scattering features, ranging from animal aggregations to internal waves to methane seeps.
- EK80 noise increased substantially above a ship speed of 7-8 kts, however, and for our purposes, where high frequency information was desirable, acoustic surveying was thus restricted to these speeds.
- Although we never encountered conditions worse than ca. 4-6' seas, EK80 data were severely degraded in almost any sea state, presumably due to bubbles in the beams. We experienced anywhere from 0 to almost 100% data loss in the seas we encountered. These issues with data loss were particularly pronounced while on station and during net tows.
- Many of the vessel's acoustic systems overlap in frequency and thus could potentially interfere with one another. The K-Sync system allowed the EK80 (all five channels), 150 kHz ADCP, and EM710 to be synchronized in a way that mitigated interference. Preliminary examination of the data suggests that acceptable data quality was maintained in all three systems. These tests were not exhaustive and should be continued in other water depths and with other systems running (e.g., 38 kHz ADCP).
- The bridge depth sounder, Doppler speed log, and 12 kHz Knudsen also interfere with the EK80 when the latter is in broadband mode; these systems can't be synchronized and for this cruise were secured other than during specific times when their output was required.

CRUISE OVERVIEW

Objectives and Science Activities

The overall objective of this cruise was to test and evaluate the R/V Armstrong for inter-disciplinary bio-physical-acoustical research. We therefore collected a variety of acoustic, biological, chemical, and physical data near the Pioneer Array and adjacent survey locations at the New England shelf break and continental slope in water depths of ca. 50 m to >2000 m. The science goals were to characterize the abundance, distribution, and vertical movements of zooplankton and micronekton concurrent to observations of physical processes, chemical conditions, and top predators, with particular focus on krill, meso-pelagic fish, and ichthyoplankton (i.e., larval fish).

Science activities included:

1. Physical Oceanography
    a. Casts with CTD/Rosette also instrumented with the NSF shared-use Digital Auto Video Plankton Recorder (DAVPR) and two Lowered Acoustic Doppler Current Profilers (LADCPs).
    b. Underway ADCP data collection.
    c. Underway sea surface and meteorology data collection.
2. Chemical Oceanography
    a. Niskin bottle seawater collection (carbonate chemistry and nutrients).
    b. Underway pCO_2 measurements (air and sea surface) with science-party supplied General Oceanics system.
3. Acoustics
    a. Assessment and application of the EK80 (e.g., noise, interference with other acoustic systems, especially the ADCP and multi-beams, narrowband vs. broadband mode)
    b. Testing the multi-beams for sampling animal aggregations.
4. Biological Oceanography
    a. Ring net tows.
    b. 1-m^2 and 10-m^2 MOCNESS tows.
    c. Deployments of the NEFSC midwater trawl.
    d. Shipboard live animal experiments (measuring acoustic material properties).
    e. Visual surveys of marine mammals and other surface-associated top predators.

Study Region and Sampling Design

The primary study site (June 17-20) was a continental shelfbreak region in the vicinity of the Pioneer Array, from the ca. 90m to 2000m isobaths. Test deployments were conducted near the 50m isobath during the transit from WHOI. Repeat occupations of a line of CTD-DAVPR stations were conducted over the course of three successive night watches. During the first pass (Transect 1, Stations 2-11) stations were conducted every 5nm between the 70 and ca. 2000m isobaths to constrain the position of the shelf-slope front. Successive passes (Transect 2, Stations 14-21; Transect 3, Stations 23-32) occupied sub-sections of this overall line. Acoustic (narrowband EK80 and ADCP) data were collected continuously along these transects. In the 12-

hr watch periods between these CTD transects, a variety of net sampling was conducted targeting regions and acoustic features of interest: two 1-m^2 MOCNESS tows at the southern and northern ends of the Pioneer Array, near the moorings with bio-acoustic systems; two 10-m^2 MOCNESS tows during day and night in the Slope Water south of Pioneer in waters deeper than 1000m; and two midwater trawls targeting fish-like scattering in shallow (100m) water and off-shelf beyond the 1000m isobath. Acoustic (narrowband and/or wideband) data were collected continuously, and the cruise track resulted in multiple repeat passes along the main study transect. Marine mammal observations were conducted during daylight hours. With only one observer and 15 hrs of daylight, effort was concentrated during transits between stations and within areas of high productivity. Marine mammals, sea turtles, sharks, and large fish were recorded. The number and species of seabirds were noted in comments as a secondary priority to record relative abundance.

Prior to the cruise, the choice of secondary study site had been kept flexible, allowing decisions to be made based on the proximity of any warm-core rings near the Pioneer Array and whether or not target organisms had already been encountered. Given that the nearest warm-core ring was too far to the east, the secondary study site (June 21-22) chosen was Atlantis Canyon and the shelf-break region to the north of the canyon. A line of CTD-DAVPR stations (Transect 4, Stations 35-42) was conducted across Alvin and Atlantis Canyons near the 250m isobath and on the following night a line was run along the axis of Atlantis Canyon and to the north through the shelf-slope front (Transect 5, Stations 46-53). Net sampling targeted acoustic features of interest observed during the CTD transects: 1-m^2 MOCNESS tows targeted plankton-like scattering at the head of Atlantis Canyon and near the shelf-slope front and a midwater trawl targeted fish-like scattering near the front. An excursion was made to the south in the Slope Water beyond the 2000m isobath, targeting the nearest region where SST exceeded 20C in the hopes of finding larval bluefin tuna. An excursion was also made to the north near the 50m isobath at the southern extent of Nantucket Shoals, a region of known methane seeps.

Sea states encountered throughout the cruise were extremely favorable, with the worst day having ca. 4-6' seas, and so conditions did not provide the opportunity to assess the vessel's performance in rough weather.

GENERAL EVALUATION OF SHIP FACILITIES AND CAPABILITIES

Laboratory Facilities

Overall we found the Armstrong to be equipped with the necessary laboratory facilities for our inter-disciplinary research needs (e.g., benches, cold storage, etc.) although we identified a number of issues and limitations, along with possible solutions:

- The main lab is spacious and the overall layout works well. However, the two doors that separate the main lab and computer lab are unnecessary and impede communication between the two. Coordinating CTD/ADCP operations (controlled in the main lab) with the EK80/K-sync/etc (in the computer lab) was difficult. It would be good to eliminate the wall and/or doors and connect the two spaces as having separate labs doesn't seem necessary. Furthermore, at present the two doors opening onto the passageway both swing outwards, which is very awkward when people are moving between the two labs.

- The U-shaped bench arrangement (forward port-side) is the nerve center of the lab during many operations (CTD, MOCNESS, etc). The arrangement of monitors and access to control of multiple instruments is great. This area gets highly congested, however, which is distracting to the main operator. Removing or moving the aft athwartship bench (or at least the forward half of it) from the U would alleviate congestion. In general it's inconvenient not to be able to move benches around; having modular/moveable benches would be preferable.
- The laminate covering on the benches is already suffering water damage in the main lab as well as wet lab. The benches should also be drillable throughout for proper tie-down.
- The sharp corners on benches and some of the upper cabinets above benches in the middle part of the lab (i.e., away from the walls) are a safety hazard.
- The white board works well for communication. Using a webcam to link the "board of lies" plan of the day to the shipboard website would be helpful.
- Cabinet and shelf storage is adequate. The locks on the cabinets are inconvenient and seem prone to breaking off; some kind of squeeze latch would be better.
- Power supplies and availability are good.
- Phone communication from the labs to other locations worked fine. It would be good to increase the volume on the phones in the main lab. The phone in the main lab was also located in the aft starboard corner but would be better positioned near the CTD control (nerve center).
- Better seats are needed in the wet lab. Because these benches are higher, bar stool style chairs were used. One of them was very hard (no cushion) and the other was on coasters (ridiculous for at-sea).

Deck Facilities

The science party generally found the deck working space and A-frame to be great: nice and large and entirely adequate for our science needs. The fantail deck space and layout works well. The main crane capabilities are excellent. The side deck is not very large but was adequate for our limited needs (deploying the CTD and drawing water from Niskin bottles). As described below with respect to specific science activities, the two over-the-side LARS have limitations. Additional general comments include:

- More cameras showing different portions of the ship would be beneficial, in particular the back deck. Also, it would be helpful to have a camera that can be trained on the wire going into the water.
- Doors don't close easily and can remain opened by accident therefore becoming a hazard, specifically the doors leading from the side deck to the changing room forward of the side deck.
- The A-frame control is positioned in a way that the A-frame itself often blocks the view of the operator.
- The 'scoreboards' displaying winch payout and tension (newly installed just before our cruise) are great.
- The garage door between the wet lab and the narrow side deck lets water into the wet lab.
- Noise on the back deck is very loud and can become mind numbing. It definitely interferes with communication and might exceed OSHA noise standards.

Science Storage

Storage was overall adequate for our needs.

- The science hold is moderate in size, but difficult to access, especially with large heavy containers, although there's probably no way around that. Shelves would be useful.
- The staging bay is very useful, including the overhead hoist. Fresh and seawater (it does not have to be uncontaminated) supplies are needed for hosing down gear and cleaning the space.
- Hooks or a rack in some area for storing science party foul weather gear, boots, etc would be useful. Currently work vests and hard hats are shared between the crew and science party are stored in the changing room, which is not connected to the main lab, and often as people take them off they don't put them back and they end up scattered around the labs. Some additional storage location for science party work vests, and hard hats would be beneficial, perhaps in the wet lab.
- Cold storage consists of one walk-in freezer in main lab and walk-in refrigerator in wet lab. These are excellent, large and with shelving for storage and tie-down. They are difficult to open once inside and one science party member found they had to push the handle and then throw his/her weight against the door, and sometimes it took a couple tries to get it right. There needs to be some way to alert others that someone is inside, like a light or a pull alarm or something.
- Fume hood locations worked well although both hoods need sinks/drains and tie down points.

Ship Performance, Navigation, and Instrumentation

Much has been made about how the ship handles in rough weather. We had extremely favorable weather and nobody had complaints about handling; most felt the Armstrong rode well compared to other vessels participants had sailed on previously. The one science party member who participated in previous Armstrong cruises commented "I find she rides not as good as Knorr but better than Oceanus. Which is what I would expect. On SVC3 we recovered a large surface buoy through the aft A-frame in moderate seas. The ship handled pretty well for that. The big test will be OOI cruise (presently underway) and OSNAP cruise where we will turnaround about 20 moorings."

- Almost everyone in the science party commented on the need to have real-time display of the ship's track and location on a bathymetric map, along with a need for display of time and distance to the next waypoint. This is crucial for planning and coordinating operations, getting ready for upcoming operations, as well as general peace of mind. This should be available throughout the vessel: in the labs and in staterooms.
- The ship's transit speed is impressively fast – at one point we were up to 12.8 kt. That was extremely helpful in minimizing transit time between stations and to/from port.
- The 3.5 kHz depth sounder did not work. It is absolutely necessary to have a screen that can be selected that has bathymetry to guide hydrographic sampling.
- It would also be useful for the science party to have access to some form of navigation software for generating waypoints and sharing them with the bridge and within the science party.
- Manuals need to be available for all science instrumentation (e.g., there was no manual for the K-Sync system). Ideally instructions (1-page 'how to' documents) will be available for all instruments too.

- The uncontaminated seawater supply was lost from time to time. Ultimately this needs to be addressed but in the short-term instructions on how to restart the system should be provided to the science party for times when the SSSG tech is unavailable.
- Access to the along track sea surface and MET data via the ship's web site was adequate, but the documentation of the data in the csv files was poor (inscrutable headers). The R/V Armstrong CSV data PDF file with explanation of the headers was incomplete. There were two sets of Barometric pressure columns, which had values that did not agree; there was no way to tell which pair was correct. The second set of barometric columns was not described in the PDF. There was no information about calibration of the sensors.

Safety

Safety was a clear priority among both science party and crew and was overall very good and on-par with UNOLS standards. The crew is diligent about clearing hazards. Some specific comments:

- CTD operations have become much safer with the new CTD arm. Although a Baltic room would have been the best and safest design, the current CTD arm is a vast improvement in safety over the tag line/tugger system.
- The water tight doors between the wet lab and main lab occasionally need to have boards installed that are about 18" tall to prevent water from entering the main lab. These are difficult to step over while holding a heavy door in rough seas. One science party member tripped on this in SVC3. Once the wet lab hangar door is replaced with a wall hopefully the need for these extra bottom parts will be eliminated.
- The top stair in the forward stair tower is almost immediately underneath the opening side of the door on the starboard side. We recommend putting yellow markings on the deck to catch the eye so someone doesn't open the door and just fall down the stairs.
- It might be a good idea to paint the padeyes/attachment points on the deck a bright color. Right now they blend in with the deck and they are certainly a tripping hazard.

IT and Communications

IT capabilities on the Armstrong seem to be a work in progress and are developing in the right direction. The comments below are undoubtedly all things that SSSG is already working on or planning:

- We were able to access satellite SST imagery on a daily basis and to upload blog posts and photos. We thus met our basic science needs in terms of off-vessel connectivity, but both were very slow and would have been substantially improved by faster connection speed. Internet access was very poor overall, particularly during the daytime, even in terms of sending text-only emails. From one science party member: "The speed of the internet/email system on board is atrociously slow. One of the slowest I have seen on any Research Ship in the past 10 years. I am not sure if WHOI switched carriers or what, but it is very inadequate. There were times when I would send a text email and had to watch the % sent increment 1% at a time. It would take more than a minute just to send text emails."
- At one point during the cruise we needed to download the instruction manual for the K-Sync, which was extremely difficult. The final solution was to ftp it from the WHOI ftp

site after having a WHOI colleague on shore move it there (another colleague who was not from WHOI had put it in dropbox for us to pick up). When trying to access this via dropbox, the connection was frequently lost and the transfer broken however the ftp protocol used seemed able to keep track of the progress of the transfer.

- The internal wireless network was reliable and fast. There were times when many people were downloading data that it slowed, but overall the internal wireless network was good, including on deck.
- The internal email system was very useful for communication within the science party and between science party and bridge. The Squirrelmail webmail software is a somewhat clunky option for internal email but adequate.
- The event logger, although a great idea and potentially extremely useful, was a consistent source of frustration. The primary problem was an intermittent breakdown of the function where the program uses user-entered time to look up GPS position and enter those data into the log. The most convenient means for recording events was thus to record the GPS time and enter the events after completion into the log, using that position look up function to identify the position at which the event occurred. Unfortunately, this function frequently failed.
- Data display on lab monitors and elsewhere was inadequate, and there also wasn't any initial briefing or online information regarding the purposes of the various screens and what could potentially be displayed on them. Many of the fields were blank most of the time. Display of bottom depth and winch payout/tension is a crucial need, as are SOG, COG, time to next waypoint. GMT seconds should be included in the displays (for use with the event logger). GPS display on the internal ship's site lagged behind the actual position.
- Data storage was confusing and accessing the data from some of the acquisition computers was very difficult/frustrating or impossible in real-time. A data storage mechanism is needed that allows for easy access and for enough space. In particular the EK80 storage filled with data quickly! Due to the EK80 operating continuously during this cruise, the data storage capability was inadequate. At one point, the science party wanted to use the shared data drive to share photos but the drive was too full to permit this and the SSSG technicians on board were unable to modify the storage architecture so that the shared drive could be used.
- More radio handsets are needed for science use. We only had two available for CTD operations.

Habitability

The science party generally found the living conditions, accommodations, and amenities to be excellent (e.g., "I thought that the boat really shone in this respect: top shelf accommodations, heads, showers were great"). A number of minor recommendations were identified to improve conditions:

- The central staterooms are especially spacious and most suitable for two people. The ones at the side of the vessel are smaller and pretty narrow for two people.
- Better soundproofing in the staterooms would be helpful as even a quiet conversation down the hall can be heard quite clearly.
- There is no real chief scientist room. Not a problem for this chief scientist and this short cruise, but it's a bit unusual. Typically the chief sci would have a single-person cabin

with private head, to maximize privacy and the ability to capitalize on often erratic sleeping hours. And a porthole is nice.

- The shades in the staterooms are not adequate to block out light. Some sort of blind is needed.
- Shelves should be installed somewhere near each bunk for alarm clocks, books, glasses, etc. Some of the fitted sheets barely fit or didn't fit.
- The curtains on the double bunks are not great. The curtains slide around when the ship is rolling, which is noisy, making it difficult to sleep. On the upper bunk, there is a space between the curtain and the ceiling so that the light comes through. Getting in and out of the upper bunk around the curtain when someone is asleep in the lower bunk is difficult.
- A safety handle and/or ladder would make it easier and safer to climb into the upper bunk as not everyone's legs are long enough to reach directly the upper bunk from the lower one.
- Another drawer could be constructed in the bottom of the lockers and/or shelves in the lockers. The lockers also need coat hangers.
- It would be helpful to supply bookshelf dimensions so people can bring plastic bins to use in lieu of drawers. Alternatively some inexpensive totes could be acquired to place in bookshelves.
- More towel racks would be helpful as would a second rack/shelf in the shower. Bath towels were a bit thin.
- The heads are difficult to flush and sometimes they don't work at all.
- There is a one-inch lip between the shower and the head. So in moderate seas, the bathroom becomes flooded. A squeegee is provided in each bathroom but a larger lip would alleviate the problem.
- The floor of the head in the Americans With Disabilities Act (ADA) room floods as the seas get rough due to the nature of the shower, making it very slippery. Should install a rubber mat or something similar. The ADA head also doesn't have anywhere to hang towels/clothes.
- Some kind of gym equipment, available to the science party as well as crew, would be nice.

Food and Galley

Most of the science party really enjoyed the food and the galley workers were helpful and friendly. A few specific comments:

- The galley could use another table for 4-6 people as there was not enough room at times during some meals.
- Most people thought the galley arrangement worked well but some commented that having everyone serve themselves was awkward, with people coming and going through the door at the same time.
- The vegetarians found the options a bit carb-heavy and protein-light and some of the meals were rather disappointing (e.g., one lunch with four meat dishes and vegetables as the only vegetarian option).
- The food put out at night for our 0200-1400 watch wasn't always adequate. Things like cereal and ramen noodles were always available but cold cuts or other things for sandwiches etc were seldom available.
- Snacks and cheese-thirty were greatly appreciated.

- The coffee was found to be weak by some, though it probably suits most people. Perhaps a Keurig coffeemaker would work so that coffee can be made fresh in small quantities and at strengths suitable to individual tastes.

Crew and SSSG Techs

The crew was excellent and helpful at all times. Some specific comments:

- The deck crew was very professional and knowledgeable, with a positive attitude to getting the job done while also being attentive to safety.
- The bridge officers were also great to work with and welcoming to visitors on the bridge.
- Most of the science party felt that a better description is warranted of the responsibilities and roles of the SSSG techs so that science parties don't have unrealistic expectations of what the techs will be doing for them. Most science party members on our SVC were expecting more tech support and felt more left to our own devices than on other research vessels. Better communication on the part of the techs and advance descriptions of their responsibilities and roles would be beneficial.

INDIVIDUAL SCIENCE GROUP EVALUATIONS

Physical Oceanography

Glen Gawarkiewicz, Gordon Zhang, Dan Torres (WHOI)

The PO group collected a combination of station-based CTD (instrumented with a lowered-ADCP) and underway ADCP data. Real-time satellite sea surface temperature data were retrieved from the Rutgers COOLroom openDAP server and used to inform sampling design. Overall these operations were very successful.

CTD: A total of 46 CTD casts were conducted, all successfully. The CTD LARS worked well although we did not have poor sea states. The CTD processing software was great- very quick and efficient. We had contoured transects within 10 minutes of the completion of the lines because the processing routines were so efficient. The SSSG Techs also did a great job instructing us initially in how to use the CTD.

ADCP: The 38 kHz ADCP was not functioning properly, due to some issue with the protective plate and fluid adjacent to the transducer heads. It was therefore not used for PO data collection, and hopefully will be fixed as soon as possible. The 300 kHz ADCP interfered with the EK80 and could not be synchronized via the Kongsberg K-Sync system and therefore was also not used. The 150 kHz ADCP, however, performed well and data were collected throughout most of the cruise. Preliminary scrutiny of the underway data look good, including when synchronized with the EK80 and other acoustic devices (see acoustics section below).

LADCP: To obtain high-resolution velocity and velocity shear in the vertical direction, two shared-use 300 kHz Lowered ADCPs (LADCPs) were deployed on the CTD. They were mounted on the CTD frame, one upward-facing and the other downward-facing, along with a battery housing installed in the base of the frame. This configuration worked well. At every CTD sampling station, the LADCPs collected acoustic backscatter signals, which can then be converted to velocity data.

SPECIFIC COMMENTS AND RECOMMENDATIONS:

- We had favorable weather and so working outside on the CTD during transit between casts was not a problem, but some way to bring the CTD inside needs to be developed (and we understand this is in the works).
- We had only one failure of the LARS, and Cris the SSSG Tech rebooted and it worked fine. When the LARS works, it is good; hopefully it will be very reliable in the long-term. It is perhaps worth thinking about what to do if it does break down during a long cruise: is there an alternative way to deploy the CTD?
- The CTD LARS works well but is slow and ideally would be sped up. Once you add the time it takes to move the CTD on a track, the time for each station will be slow. But once a procedure is established, efficiency will improve.
- A couple of times we had to stop operations and it will be necessary to institute a protocol with terminology that spans the two extremes of " hey, stop when you get a chance, I forgot to take the protective cover off" to "emergency stop." Evidently a good portion of the deployment and/or recovery is automatic and this should be discussed at the science briefing or with the CTD group before ops commence as this was new to our group and required some adjusting.
- The joint analysis of the CTD, ADCP, and satellite SST data in real-time was extremely valuable for understanding the regional context and also for adjusting sampling strategy during the cruise (i.e., adaptive sampling). Due to interference between the ADCP and EK80 the ADCP was shut down for periods of time. Progress was made on synchronizing these systems to mitigate interference (see Acoustics section below) and it will be important to solve this issue in order to keep the shipboard ADCP running at all times during future cruises where EK80 data are also of interest.
- There were indications of interference between the LADCPs and the EK80 200 kHz channel when the latter was operated in broadband mode; after identifying this issue, the EK80 was only operated in narrowband mode during CTD casts. The degree to which the interference affected the quality of the LADCP data awaits further analysis.
- Downloading the SST data was extremely difficult and constantly interrupted. I recommend having a separate Internet channel with higher bandwidth or priority for access real-time data (e.g., SST and SSH) from other sources for adaptive sampling.

Chemical Oceanography

Aleck Wang (WHOI)

The chemical oceanography group conducted a combination of station-based profiles and underway measurements. Seawater was collected via Niskin bottles at a subset of the CTD stations for profiles of carbonate chemistry (TA and DIC) and nutrients. Underway automated measurements were conducted continuously using a General Oceanics pCO_2 system and uncontaminated seawater (UCSW) supply.

Bottle Sampling: At total of 20 stations were chosen to collect water samples for dissolved inorganic carbon (DIC), total alkalinity (TA), and nutrients in the water column. This effort resulted in 155 bottle samples of DIC/TA and nutrients respectively. The weather condition was good for all deck sampling, except for a few rain events (see below). Bottle sampling went very well and we did not experience any major issues. The Niskin bottles were generally in good condition, and mis-triggering occurred only in a few cases.

Underway pCO_2 measurements: The General Oceanics pCO_2 system operated well during the cruises. No instrument issues occurred. The SSSG technicians were very helpful during the mob period in setting up the underway air sampling line from the front of the ship. The uncontaminated underway water line did not experience major issues during the cruise.

SPECIFIC COMMENTS AND RECOMMENDATIONS:

- Having to collect water samples from the exposed deck was OK only because the weather was so good. Improving the wet lab access for the CTD is already under discussion and needs to be implemented.
- At the time of our cruise, the uncontaminated seawater supplies to the wet and main lab were a work in progress. We were able to jury rig valves and tubing in order to have one SW supply to the wet lab for net sample processing, one to the main lab for live animal experiments, and one to the main lab for underway carbonate chemistry sampling (see above). It would be preferable to have a fixed spigot next to each of the sinks, as well as other valves installed for seawater supply.
- The UCSW line generally provided sufficient flow to supply underway CTD, pCO_2, and flow-through water for live-animal experiments. However, the underway water was stopped on a few occasions due to air bubbles trapped in the underway pipe. This happened when the weather was generally good. It raised the concern that the underway seawater line may experience air-lock issues when the sea state is unfavorable. The science party was told by the SSSG techs that this issue can be severe when the ship experiences heavy weather.
- There is no covered area for water sampling from the CTD package. There were rain events during the cruise, and the chemistry team experienced some difficulties collecting bottle samples as rainwater can get into the samples, which causes contamination. We strongly recommend that a covered area near the CTD package be established so that water sampling can be protected from precipitation.
- There is limited storage space for gas tanks.

Biological Oceanography

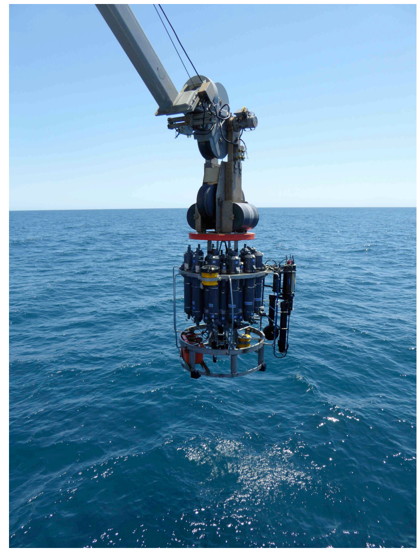
Gareth Lawson, Carin Ashjian, Peter Wiebe, Joel Llopiz, Phil Alatalo, Chrissy Hernandez (WHOI)

A variety of net sampling systems (ring net, 1-m^2, and 10-m^2 MOCNESS) as well as an optical sampling system were deployed over the course of the cruise for biological sampling. These operations went smoothly and the A-frame and stern are well equipped for large net work. The deck crew and bridge likewise did an excellent job, despite most of them not being familiar with these operations. As elaborated below, a common and strong concern among the biologists, however, was the lack on an ability to tow nets from the starboard side.

Ring Net: Joel Llopiz led the ring net sampling (a 1-m diameter circular plankton net with 500 um mesh), but we ended up only doing a test deployment of the ring net since we never encountered conditions meriting its further use. The ring net was deployed over the side, and we can (strongly) reiterate what the crew, ship ops personnel, and scientists already know: there needs to be a way to tow gear from the side of the ship. Capt. Sheasley and the crew were curious how the gear would behave when we towed it from the aft LARS, so we attached a ~75 lb weight to the end of the wire and then attached the ring net to the wire with a book clamp about a meter above the weight. We started by making only about 1 kt of way through the water (ideally the gear would be towed at 2-3 kts), and lowered the net to about 5 m depth. The wire quickly took up an angle of ~20-25 degrees and jumped over the edge of the sheave at the end of the LARS. We considered rigging a stay that ran from forward from the wire with a shackle that the wire could slide up and down through. But a plankton sample wasn't needed at that station, and we decided not to waste the time then. It's worth noting that the ring net we used is very light and small, and repeatedly deploying it astern would be overly cumbersome. Furthermore, in our case, the interest was in plankton in the upper 10 m of the water column, and towing astern would have meant that the upper few meters would have been disturbed by the ship passing through the water, which would have been unacceptable scientifically.

MOCNESS: The MOCNESS operations went extremely well, in large part due to how well the Bosun Pete Liarikos ran the deck, ensuring that the launch and recovery of the large and small MOCNESS went smoothly and safely, along with the skills of the winch operators. The bridge likewise is very comfortable towing instruments over the stern and was able to accommodate our particular course requests nicely (e.g., adjusting course to account for wind and currents in order to maintain a requested tow trackline). The aft deck was very spacious and conducive to this work. At 11.2 x 15.4 feet in size, the 10-m^2 MOCNESS is a large net system and somewhat daunting to the neophyte. Nonetheless, the large A-frame, coupled with science party-supplied rollers installed on the stern along with a stand system and tuggers, made the deployment and recovery straightforward. Between tows the large MOC was tied down immediately forward of the A-frame, while the small MOC was stored on the port side of the back deck; both systems were towed with the trawl winch and 0.680" wire. Deploying the 1-m^2 system required lifting it with the crane, lowering it into the center of the 10-m^2 system then taking up tension with the trawl winch for deployment. This was a slow and cumbersome process. Furthermore, although we had favorable weather throughout the cruise, towing the 1-m^2 over the stern is sub-optimal as it is affected by ship's heave. The latter issue could be addressed if the trawl winch had motion-compensating capabilities, although prop wash affecting the net samples would remain an issue. Overall it would be much preferable to be able to tow the 1-m^2 from the starboard side, to reduce the impact of heave and to allow rapid and simple transitions with over-the-stern operations (like the large net). Another component of the MOCNESS work was the processing of plankton samples in the wet lab and examination in the main lab under microscope. Some live-animal experiments were also conducted in the main lab. Both labs are spacious and accommodated these activities easily.

DAVPR: The NSF shared-use Digital Auto Video Plankton Recorder (DAVPR) was installed on the CTD package for optical imaging of zooplankton. The DAVPR is an autonomous system that can be deployed on its own, with either conducting or non-conducting wire. Typically, however, to make best use of wire time we attach it to the CTD package. The large size of the DAVPR makes mounting it in the rosette difficult at best (in comparison with the smaller, earlier model AVPR). On previous cruises we have used an auxiliary-stand attached beneath the CTD frame in which the DAVPR can be mounted (it can alternately be integrated into the rosette in place of some of the Niskin bottles but this reduces the number of bottles for the chemists and also makes it difficult to remove/replace it during the cruise). The CTD LARS on the Armstrong reduces substantially the maximum height of the CTD package, however, and the distance between the deck and the collar of the LARS did not allow for us to attach our auxiliary-stand (19" in height). Instead the DAVPR was attached to the outside of the CTD frame, between two of its bumpers/guard rails (see photograph). Normally this would be a very unwise location as it is entirely exposed if the CTD hits against the side of the vessel; with the LARS, however, the CTD comes free of the arm only when it is in or very near the water, and the risk of hitting the side of the vessel seems negligible in any kind of workable seas. Clearance over the rail was an initial concern with the added diameter of the CTD-DAVPR package, since the CTD clears the rail at an angle, but proved not to be a problem. Overall this arrangement worked extremely well. The instrument was at a convenient height for operation and for swapping out batteries. Only a few Niskin bottles were blocked by the instrument and access to these bottles was not horribly inconvenient. One problem with this arrangement, however, is that for some applications CTD casts are needed below 1000 m (the maximum depth rating of the DAVPR) and the DAVPR needs to be detached. Having the auxillary-stand makes this process easy as it was designed with rails to allow rapid removal. Having the DAVPR attached to the side of the CTD as was the case for the present cruise would require more time and effort and would not be as safe a process. The load handling system that deployed the CTD/DAVPR package moved rather slowly much of the time and occasionally lurched and exhibited strange up and down motions of the package while bringing it on board, which did not instill complete confidence in the system. (Note, the two DAVPR science team members were responsible for running the deck for all of the CTD/DAVPR deployments).



Overall, the ship worked very well for DAVPR applications. One concern is that the CTD/DAVR package could not be brought under cover when on deck (such as in a hanger or Baltic room). This is a recognized issue for the Armstrong. For this operation, swapping out the battery during rainstorms was somewhat problematic, since the underwater can containing the battery must be opened to remove/replace the battery. This then required sheltering the open can on the open deck. The CTD/DAVPR was accessed through the rolling door in the wet lab. This worked very well because most of the cruise saw fine weather with no need to barricade the door against seas. The wet lab was a fine location from which to base deployment operations during this cruise, however in heavier weather that laboratory would be a difficult place to work if water entered the laboratory or if the side door cold not be used.

SPECIFIC COMMENTS AND RECOMMENDATIONS:

- A capability to tow instruments over the side is crucial, to allow efficient transition between operations that have to be done over the stern (e.g., the 10-m^2 MOCNESS or midwater trawl) with smaller towed instruments (e.g. the 1-m^2 MOCNESS or ring net) and to reduce the impact of ship's heave and prop wash on smaller and lighter packages.
- After much deliberation, we were able to devise the method described above for attaching the DAVPR to the CTD frame in order to deploy both concurrently with the automated LARS.

The maximum height limit imposed by the LARS could limit use of other systems, in cases where they have to be attached below or above the CTD frame, or taller rosettes such as seem standard on other ships (e.g., Sikuliaq, Thompson, Healy).

- All of the nets were rinsed out with a seawater line to the back deck rigged by the engineers for our purpose and that required calling the engine room to get them to turn it on. This is cumbersome and at times led to delays (e.g., when the right person in the engine room was eating). Clearly, a dedicated seawater hose, either constantly on or controllable from the deck, would be preferable.
- Sample processing in the wet lab went well and the facilities are very suitable: a large sink and nearby fume hood. The chemicals used to preserve samples had to be stored in the hazmat locker in the main lab; a hazmat locker in the wet lab would be preferable as it would minimize transport.
- The positioning of the two sinks in the main lab is somewhat restrictive as they're both right next to one another. We had two science groups who needed sinks, one for live animal incubation and the other for an underway sampling system. The positioning of the sinks required that these two groups operate immediately next to one another. This worked for our short cruise but spacing out of the sinks in the lab might be desirable.
- As described above, a functional readout of the ship's data is needed, especially the wire out and rate information, which is crucial during net tows.

Acoustics

Andone Lavery, Gareth Lawson, Peter Wiebe, Tim Duda, Serdar Sakinan (WHOI); Dezhang Chu (NOAA NWFSC); Mike Jech, Jennifer Johnson (NOAA NEFSC)

The Armstrong is equipped with an impressive variety of acoustic systems, including a broadband scientific echosounder (Kongsberg Simrad EK80, with transducers at center frequencies of 18, 38, 70, 120, and 200 kHz), three ADCPs, and two multi-beams. Application of acoustics to biological studies is a specialty of our group, and a large number of acousticians and bio-acousticians participated in the cruise, including representatives from NOAA Fisheries, where use of Simrad EK systems in assessment surveys is routine. Valuable data were collected with all three types of acoustic systems: EK80 observations were made of a variety of biological aggregations and layers, as well as of methane seeps, internal waves, and thin layers likely caused by the physical structure of the water column; ADCP measurements were made of currents (see above); multi-beam observations in 3D were made of fish schools and methane seep plumes. The text that follows focuses specifically on the EK80 and is based on very preliminary, qualitative scrutiny of the data.

Calibration: Prior to the cruise, a series of calibration exercises were conducted of the EK80 with the vessel at dockside. This involved suspending standard targets (small metal spheres) below the vessel and directly in the path of each of the five EK80 transducers. A wireless calibration system developed by NOAA NEFSC was used to suspend and position the spheres. Although positioning the targets was complicated by the dock lines and by the shallow bottom, the calibrations were overall successful. Additional follow-up calibrations are planned for later in 2016 and full details will be reported elsewhere.

Noise: Tests were conducted of noise levels at varying ship speeds. The maximum power settings are lower for the higher frequency channels. Sound also attenuates more rapidly with range at higher frequencies, such that overall the maximum range attainable at each channel decreases with frequency. The maximum range to which organisms can be observed is also a function of how strongly they scatter sound (e.g., large fish with a swimbladder can be detected to larger ranges than small zooplankton). Noise from the ship can affect data quality by introducing occasional 'spikes' or other unwanted returns and by reducing the maximum sampling range.

In transit to the study region we conducted tests of noise levels relative to vessel speed and found that noise increased substantially on the higher frequency channels with the EK80 in broadband mode above 7-8 kt. Since zooplankton are a target of our work and the high frequency information is crucial, this speed was thus selected for acoustic surveying throughout the cruise. We were also varying power levels at the time, from ½ of the maximum allowed to maximum at each of the higher frequency channels (70, 120, 200 kHz). We did not do extensive tests but noise appeared more pronounced when the bow thruster was in use, and occasional bursts of artefactual scattering were evident at regular intervals when the DP system was in use. Conditions were calm and although the bathymetry was changing rapidly we were mostly in shallow waters, so these tests were not exhaustive and should be repeated in worse seas and in deep water.

Simultaneous vs. Sequential Mode: The five channels on the EK80 can be fired either simultaneously or sequentially. However, triggering sequentially may reduce the ping rate significantly, especially when the scattering layers of interest are deep. In narrowband mode the transmissions are different enough in frequency that simultaneous pinging is fine. Tests were conducted to determine whether pinging sequentially in broadband mode, where the frequency bands spanned by each channel were often contiguous with adjacent channels, affected data quality.

Broadband Mode: A key feature of the EK80 is its capability to operate in broadband, as well as narrowband, mode. Relative to its narrowband, multi-frequency predecessor echosounder, the EK60, this broadband capability offers important improvements in range resolution, noise reduction, and the ability to distinguish between different kinds of scatterers. Over the course of the cruise, data were collected using multiple combinations of channels in broadband and/or narrowband mode. All five channels were successfully operated in broadband mode. The 18 and 38 kHz channels, whose transducers are narrowband, are blocked from being used in broadband by the factory-installed EK80 software. Working in collaboration with Simrad, our research group has previously used the 18 and 38 kHz Simrad transducers in a quasi-broadband mode (i.e., applying broadband signals to narrowband transducers), and for this cruise we received permission from Simrad to conduct tests of the 18 and 38 kHz in broadband mode, at low power and spanning only restricted bands. These went smoothly. Data analysis is presently underway.

Overall Performance: During the first portion of the cruise when sea states were flat calm, EK80 data were of high quality. As conditions became mildly rougher, it became evident that EK80 data quality was severely degraded in almost any sea state. We experienced anywhere from 0 to almost 100% data loss in the sea states we encountered. Presumably this was due to bubbles being swept under the hull and over the transducer faces causing complete loss of the transmit pulse. These issues with data loss were particularly pronounced while on station and during net tows; i.e., times when the DP system was turned on and the vessel was stationary or moving slowly (1.5 – 2.5 kt). The dropouts on the EK80 system were so many that the echosounder data were almost useless. For instance, when towing the midwater trawl at low ship speed (ca. 2 kt) into a low sea state (ca. 4-6') it was nearly impossible to track fish schools because of the extremely high rate of data loss.

Interference and Synchronization: Tests conducted during the initial transit from port to the study site and later in the cruise indicated that a number of acoustic systems interfered with the EK80, manifesting as unwanted spikes in the data. Some of these interference issues were later addressed through use of the Kongsberg K-Sync system.

Bridge Sounder
The bridge depth sounder (50/200 kHz?) caused obvious interference and was secured for the duration of the cruise, other than for navigation during the periods immediately after departure and before arrival.

Speed Log
The Doppler speed logger (400 kHz?) interfered when the EK80 200 kHz channel was in broadband mode. The logger was secured during acoustic surveying, other than during times when the bridge or science party required speed through the water (e.g., during net tows).

Knudsen
The Knudsen 3.5 kHz was not working but the Knudsen 12 kHz interfered with the EK80 18 kHz channel when the latter was in the broadband mode and pinging simultaneously. The 12 kHz was thus secured throughout the cruise, other than immediately before and sometimes during each CTD cast.

ADCP
The 150 kHz ADCP interfered with the EK80 120 kHz channel when the latter was in broadband mode; the 300 kHz ADCP interfered with the EK80 200 kHz in broadband; the 38 kHz ADCP was not operating but would certainly have interfered with the EK80 38 kHz channel, in broadband and narrowband mode. For the first half of the cruise, EK80 data were collected in narrowband mode during nighttime PO watches concurrent to use of the 150 kHz ADCP. During daytime BIO watches, EK80 data were collected in broadband mode and the 150 kHz ADCP was secured other than at stations (to cross-calibrate the lowered ADCP systems attached to the CTD).

Continuous concurrent collection of EK80 and ADCP data with the EK80 in broadband mode is obviously desirable and so over the course of the cruise a great deal of effort was put into synchronizing these systems. The Armstrong has a Kongsberg K-Sync system that allows different acoustic systems to be synchronized, giving the user control over which system is master and which slave(s) as well as over the sequence of pinging and inter-ping intervals. The 300 kHz ADCP (RDI Workhorse Mariner) can not be easily synchronized with other instruments and is not controlled by the Kongsberg K-Sync. It was thus secured for the duration of the cruise.

The 38 and 150 kHz ADCPs (Ocean Surveyors) can be controlled with K-Sync. Dezhang Chu of NOAA NWFSC had previous experience with the K-Sync system and over the course of the cruise was able to set it up such that all five EK80 channels and the 150 kHz ADCP were synchronized. No interference was evident when the systems were synchronized. Synchronizing the systems involves alternating pinging between the two, which increases the overall ping interval and the concern with ADCPs is that the ping rate will be too slow and data quality will be reduced or impaired; preliminary examinations, however, suggested that data quality was high and uncompromised. For the latter half of the cruise, data were thus collected concurrently during transits with the 150 kHz ADCP and EK80 in broadband mode. Tests were also conducted synchronizing the 38 kHz ADCP as well as the EK80 and 150 kHz ADCP (and EM710 multi-beam, see next). As the 38 kHz ADCP was not operating properly we were not able to confirm how synchronizing might affect its data quality (or that of the other systems), but the tests at least confirmed that it could be synchronized and that doing so didn't increase the ping interval to a level that affected the other systems.

Multi-beam
The Kongsberg EM710 multi-beam spans a frequency band of 70-120 kHz that overlaps and interferes with the EK80 70 and 120 kHz channels but can also be synchronized using K-Sync. Towards the end of the cruise in regions of fish schools and methane seep plumes, where 3D observations from the multi-beam were of interest, tests were made synchronizing the EM710. This was in a mostly shallow (<100m) region of varying bathymetry. The EK80, 150 kHz ADCP, and EM710 were all synchronized with no interference, and at a substantial ping rate. With the EK60 it is possible to provide a bottom depth estimate to the K-Sync in order to allow it to adjust the ping rate as water depth varies; with the EK80 this capability is not available, at least at present.

SUMMARY COMMENTS AND RECOMMENDATIONS:

- EK80 noise increased substantially above a ship speed of 7-8 kts and for our purposes, where high frequency information was desirable, acoustic surveying was thus restricted to these rather slow speeds.
- EK80 data quality was severely degraded at many speeds in many conditions, particularly as sea state increased, due to the apparent presence of bubbles in the beams.
- Much progress was made towards enabling simultaneous data collection from the EK80 echosounder and other acoustic systems. The K-Sync system allowed the EK80 (all five channels), 150 kHz ADCP, and EM710 to be synchronized in a way that mitigated the interference between these systems. Preliminary examination of the data suggests that acceptable data quality was maintained in all three systems. These tests were not exhaustive and should be continued in other water depths and with other systems running (e.g., 38 kHz ADCP). Ultimately a sync protocol needs to be established that can be followed by any of the SSSG techs that happens to be on any cruise.
- The bridge depth sounder, Doppler speed log, and 12 kHz Knudsen also interfere with the EK80 when the latter is in broadband mode; these systems can be secured other than during specific times when their output is required.
- Access to the EK80 data was so slow that it was essentially impossible to retrieve the data in real-time, which is a major limitation for real-time analysis and decision-making. These data cannot be accessed over the wireless network and required either direct connection over the

wired network or transfer via a portable hard drive. This makes adaptive research operations almost impossible since many of the adaptive operations may need real-time or nearly real-time data processing capability using special software (such as Echoview and Matlab), other than manufacturer provided standard data acquisition software (EK80). These software programs require direct access of the raw data.

- The EK80 can be displayed on any monitor throughout the ship, which is great. Presently though the EK80 can only be controlled in the computer lab. It would be advantageous to be able to move control to other locations, minimally at the CTD station in the main lab. It would also be good to have the ability to modify independently the EK80 (and multi-beam) *display* parameters at any terminal throughout the ship, but to restrict the ability to change any critical parameters governing data collection (e.g., ping rate, maximum range, etc) to a single designated control computer (e.g., in the computer lab or main lab). This capability was available for the EK60 and presumably is possible for the EK80.
- One or two keyboard/monitor setups should be added in the computer lab, so that the multi-beam sonar PCs and the EK80 PC do not share a keyboard, and can be attended to simultaneously.
- When running the EK80 the two monitors both show the same output as the PC only has one display output port. It would be very helpful to be able to use the two monitors independently, so that other tasks can be attended to without blocking view of the EK80 data collection software.
- Presently the K-Sync software is only on the EK80 data collection computer such that the K-Sync settings can't be adjusted without blocking the EK80 display. The K-Sync software could be moved to a different computer, or as described above the EK80 PC could have two independent monitors. Like for the EK80 it would also be helpful to be able to control the K-Sync from terminals outside the computer lab, minimally in the main lab CTD control station.
- As described above, communication between the main lab and the computer lab is made difficult by the two being separated by a hallway and two doors. Scientists in the operation room don't know the status of other scientific activities. This was particularly a problem in coordinating EK80/multi-beam/K-Sync operations with other operations such as net tows and ADCP data collection.
- Access to analysis software for the EK80 and multi-beam data, such as Echoview, would be advantageous. The EK80 data collection software would also benefit from having MS Word and Excel, to help with note taking, and ideally also Matlab for data analysis.
- For trouble-shooting it is also important that all manuals be available on the ship (e.g., the K-Sync manual was not onboard).
- Overall the SSSG Techs will need to become fully familiar with the setup and operation procedures of the major acoustic instruments including EK80, ADCPs, EM122/710, and K-Sync systems.

Fisheries/Trawls

Mike Jech, Jennifer Johnson (NOAA NEFSC)

The R/V Armstrong, like other UNOLS vessels, is not designed to tow fish trawls as it lacks port and starboard trawl winches, a constant tension winch, a trawl ramp, trawl monitoring systems, etc. However, the vessel does have a single oceanographic winch with wire capable of towing sufficient tension for a small trawl along with a large stern A-frame. One objective of the cruise was therefore to evaluate the feasibility of deploying and retrieving a midwater trawl, a highly valuable capability for fisheries and ecosystem studies. The net was a modified balloon-style trawl, with a ca. 8 x 6m mouth opening (while "fishing") held open while deployed with two trawl doors, 820lbs each. As such the net is comparatively small by fisheries standards but large relative to typical nets deployed from UNOLS vessels.

Due to the vessel's configuration, we developed a bridle system that allowed the midwater trawl to be towed by the trawl winch. In this case the bridle was used to tow the net as well as deploy and retrieve the net. A portable winch supplied by the UNOLS East Coast winch pool and mounted to the back deck was also employed. Schematics and detailed descriptions of the bridle system and deployment/recovery operations are found in the appendix.

Over the course of the cruise we successfully completed three midwater hauls. Although the set and recovery processes are a bit complicated due to the need to connect the tow bridles to the doors while the net is under tension, all three deployments and recoveries went smoothly

SPECIFIC COMMENTS AND RECOMMENDATIONS:

- We were able to connect and disconnect the tow bridles to/from the doors with the net under tension by relieving the strain with appropriate "stopper" chains. This worked fine in the calm sea states encountered during the cruise. In rougher conditions or for a cruise where midwater trawling was a primary objective, some form of stanchion would be desirable to support the trawl doors (similar to the 'door gallows' on fishing vessels).
- Vessels designed for fish trawls have paired port and starboard trawl winches. It might be possible to use a portable winch to supplement the Armstrong's trawl winch. This would be particularly beneficial in using larger nets.
- Real-time measurements (i.e., measurements from the net transmitted either acoustically or with a wired system) of trawl mensuration (e.g., door spread, mouth vertical and horizontal opening) and location (depth and position relative to the vessel) in the water column are critical for using the midwater trawl to target acoustically-observed features and/or towing the net near the seabed. This was not accomplished on the Armstrong. On fishing vessels, such measurements are collected with sensors attached to the headrope which communicate with the vessel via an electronic conducting cable (i.e., "third wire") and a constant tension winch. In lieu of these, it may be possible to use the vessel-based ultra short baseline (USBL) system to monitor the location of the net. There are also acoustic-based mensuration systems that could be tested, but require a hydrophone be towed during the trawl haul.

Marine Mammals

Jennifer Gatzke (NOAA NEFSC)

One marine mammal observer from NOAA NEFSC participated in the science verification cruise to assess the capabilities of the ship for surveys of marine mammal and seabirds. Visual surveys employing naked eye and 7X50 binoculars of marine mammals, sea turtles, sharks, and fish of interest (tuna, billfish, and ocean sunfish) were conducted continuously during daylight hours while the vessel was in transit along survey lines, at 7 kts. This speed was chosen to optimize EK80 acoustic data (see above) and is typically the minimum speed at which one might conduct a line transect or exploratory survey for top predators.

The Armstrong offers a designated marine mammal observation deck forward of the wheelhouse on the 02 deck at 34' above water line. The wheelhouse also offers a protected secondary platform at 38' above the water line. The purpose of the mission to Pioneer Array was to assess the quality of the two available platforms for future use in a marine mammal and/or seabird abundance or cetacean biological survey. The first three days of the survey were therefore conducted from the designated marine mammal observation deck while during the last two days observations were conducted from inside the wheelhouse.

The marine mammal deck has base plates for big eye (25X150mm lenses) binoculars but the necessary stands are not yet mounted in place and would need to be installed for any dedicated marine mammal cruise. A permanent laptop bench (aka the picnic table) is mounted on the port side of the deck and outlets are available for a data collection laptop. While there is currently no Ethernet plug-in present beside the desk, there is a wireless router. With an unobstructed view from this marine mammal observation deck (all but about 90 degrees directly behind the ship), attention during the survey was focused on the forward 180 degrees (beam to beam). The wheelhouse provides a 360 degree partially obstructed view (due to the window frames and infrastructure), sun protection, and a power source.

SPECIFIC COMMENTS AND RECOMMENDATIONS:

- The marine mammal observation deck is quiet (a great advantage for recording sightings) and has a broad uninterrupted view forward and out to ~135 degrees on each side, but it is difficult to access a view off the stern. In order to track animals that are diving and resurfacing (when studying sperm whales, right whales, and beaked whales in particular) it is important to be able to have a 360 degree view. Currently one needs to go down a deck (from the 02 marine mammal observation area to the 01 deck) and around to the back of the ship in order to achieve this.
- If we were to conduct a dedicated marine mammal line transect distance survey we would need to mount big eye binoculars to the deck and it would be highly desirable to have access to some shade/cover from the sun. I realize this would be difficult due to the need for an unimpeded view from the bridge, but we could possibly mount small temporary covers that could be used only while on effort. A wind break/barrier would also be advantageous in windy and rough weather. This could be accomplished by making the rails on the 02 deck a solid structure or lace sail material between the railings (has been done recently on the RV Bigelow and it can be easily removed).
- An Ethernet connection port on the marine mammal observation deck would also be desirable as we typically want to plug into the ships computer system for real time data streaming into our survey software, allowing the collection of GPS and environmental data like depth and water temperature.
- Notwithstanding bad weather conditions it is most desirable to observe from outside. Observations from the wheelhouse went well during the cruise and would be great for times of poor weather. They do not allow for mounting big eye binoculars, but the 360 degree view is very nice.
- Although it was not permissible during our cruise due to safety concerns, the most ideal position for conducting these surveys would be on the flying bridge where we would have the best height advantage and 360 degree view. There would also be no impediment to adding a sun shade and wind break (as there is already one in place). The smaller radar would

presumably need to be raised so as not to be a safety concern. The only disadvantage I can see to this might be the stacks emitting exhaust at that level.

- Though not a part of the present cruise, the main deck looks ideal for other operations often conducted during marine mammal-focused cruises, including small boat securing and handling, as well as deployment/recovery of hydrophone arrays.

APPENDIX I – SCIENCE PARTY LIST

BIO/ACOUSTIC

Dr. Gareth Lawson	WHOI Biology
Dr. Peter Wiebe	WHOI Biology
Dr. Serdar Sakinan	WHOI Biology
Dr. Carin Ashjian	WHOI Biology
Mr. Philip Alatalo	WHOI Biology
Dr. Joel Llopiz	WHOI Biology
Ms. Christina Hernandez	WHOI Biology
Dr. Andone Lavery	WHOI AOPE
Dr. Timothy Duda	WHOI AOPE
Dr. Dezhang Chu	NOAA NMFS NWFSC
Dr. Michael Jech	NOAA NMFS NEFSC
Dr. Robert Johnston	NOAA NMFS NEFSC
Ms. Jennifer Johnson	NOAA NMFS NEFSC
Ms. Jennifer Gatzke	NOAA NMFS NEFSC

PO/CO

Dr. Glen Gawarkiewicz	WHOI PO
Dr. Gordon Zhang	WHOI AOPE
Mr. Jacob Forsyth	WHOI PO
Mr. Daniel Torres	WHOI PO
Dr. Aleck Wang	WHOI CO
Dr. Yabin Men	WHOI CO

OTHER

Mr. Joe Mccabe	WHOI SSSG
Mr. Cris Seaton	WHOI SSSG
Mr. Daniel Cojanu	UnderCurrent Productions
Ms. Elise Hugus	UnderCurrent Productions

APPENDIX II – MIDWATER TRAWL DESCRIPTION AND PROTOCOLS

Figure 1

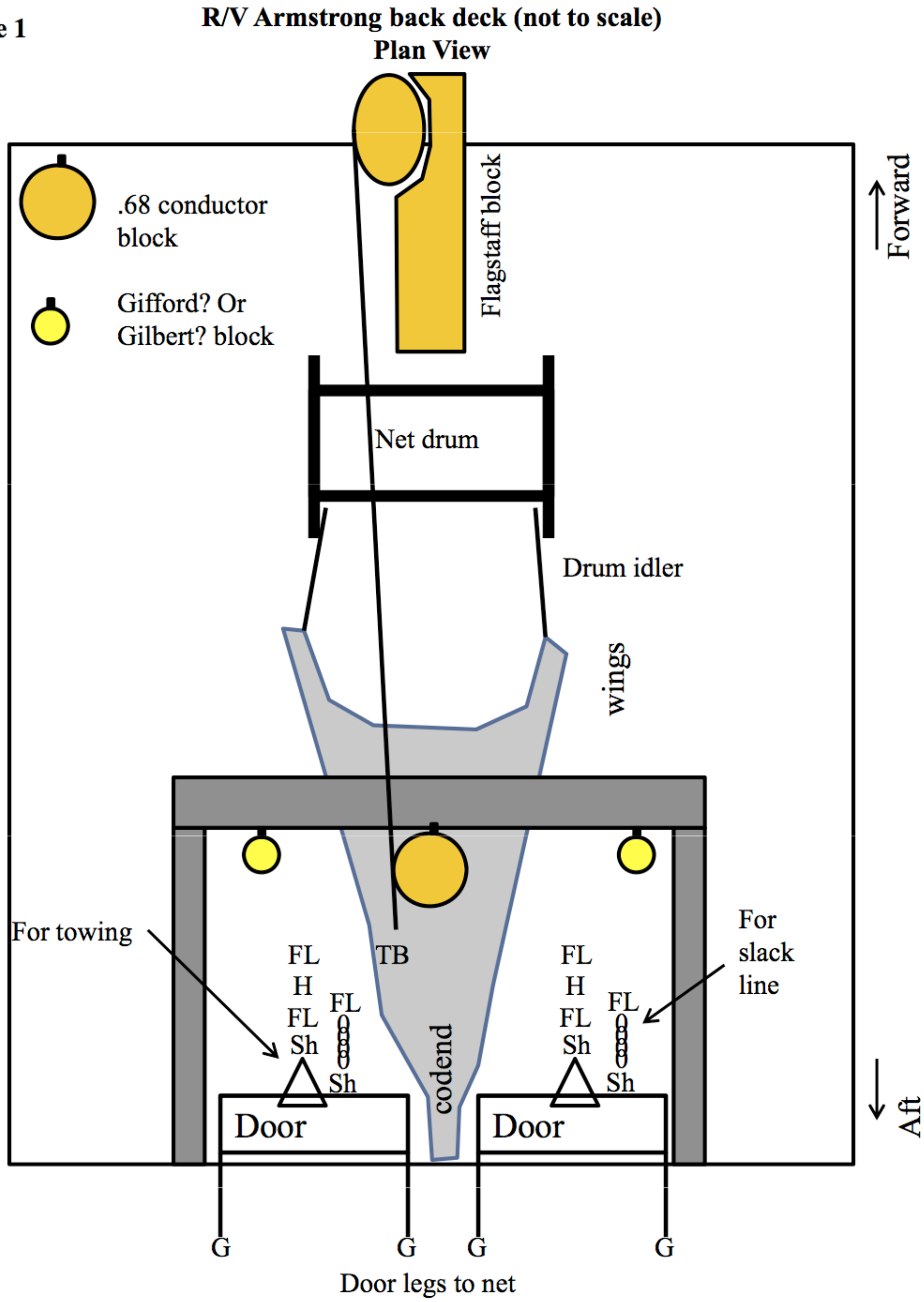


Figure 2

Tow-bridle configuration for towing a midwater trawl on the R/V Armstrong

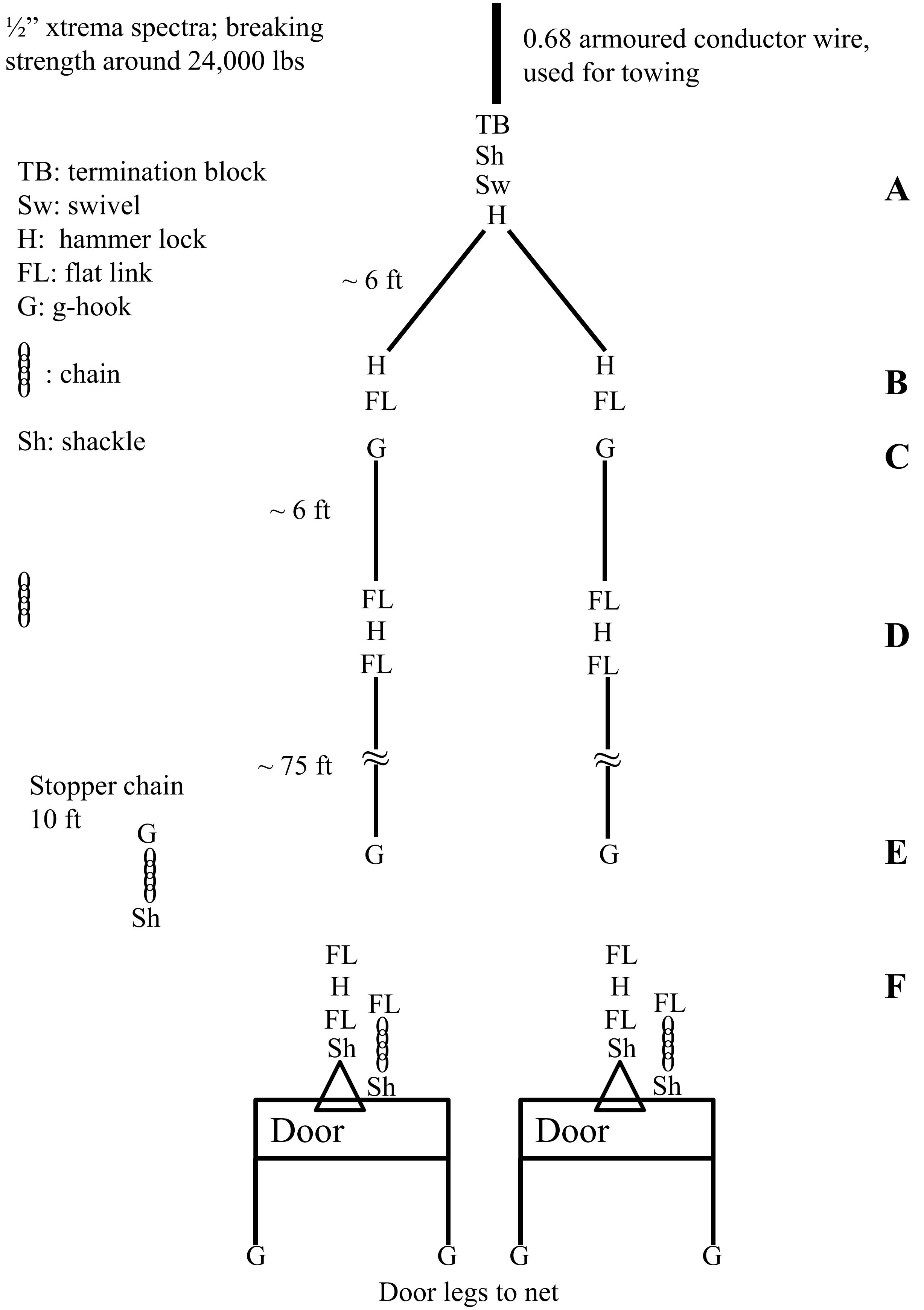


Figure 3

TB: termination block
Sw: swivel
H: hammer lock
FL: flat link
G: g-hook

0
8 : chain
8
0

Sh: shackle

Drum idler
~ 95 ft
Started with 100 ft, but eye splices on each end shorted by about 5 ft

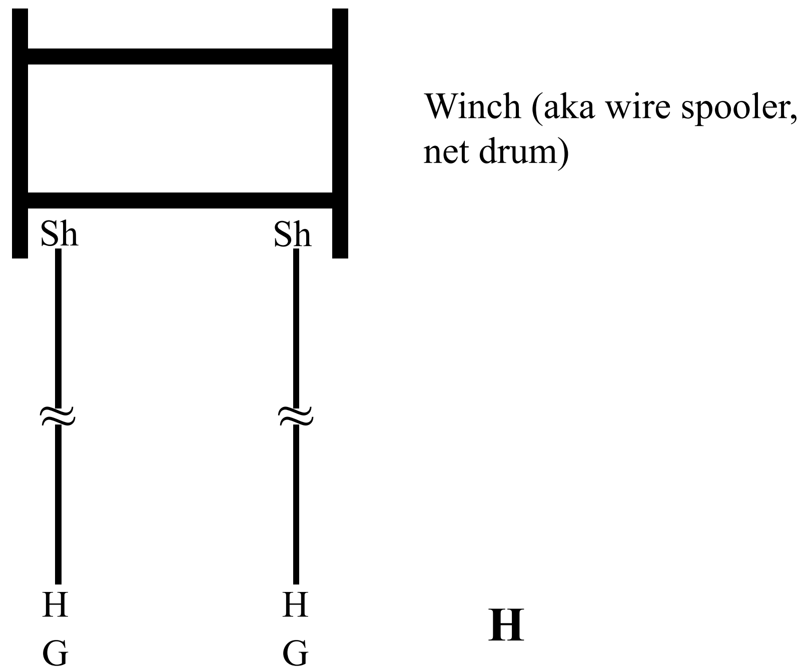
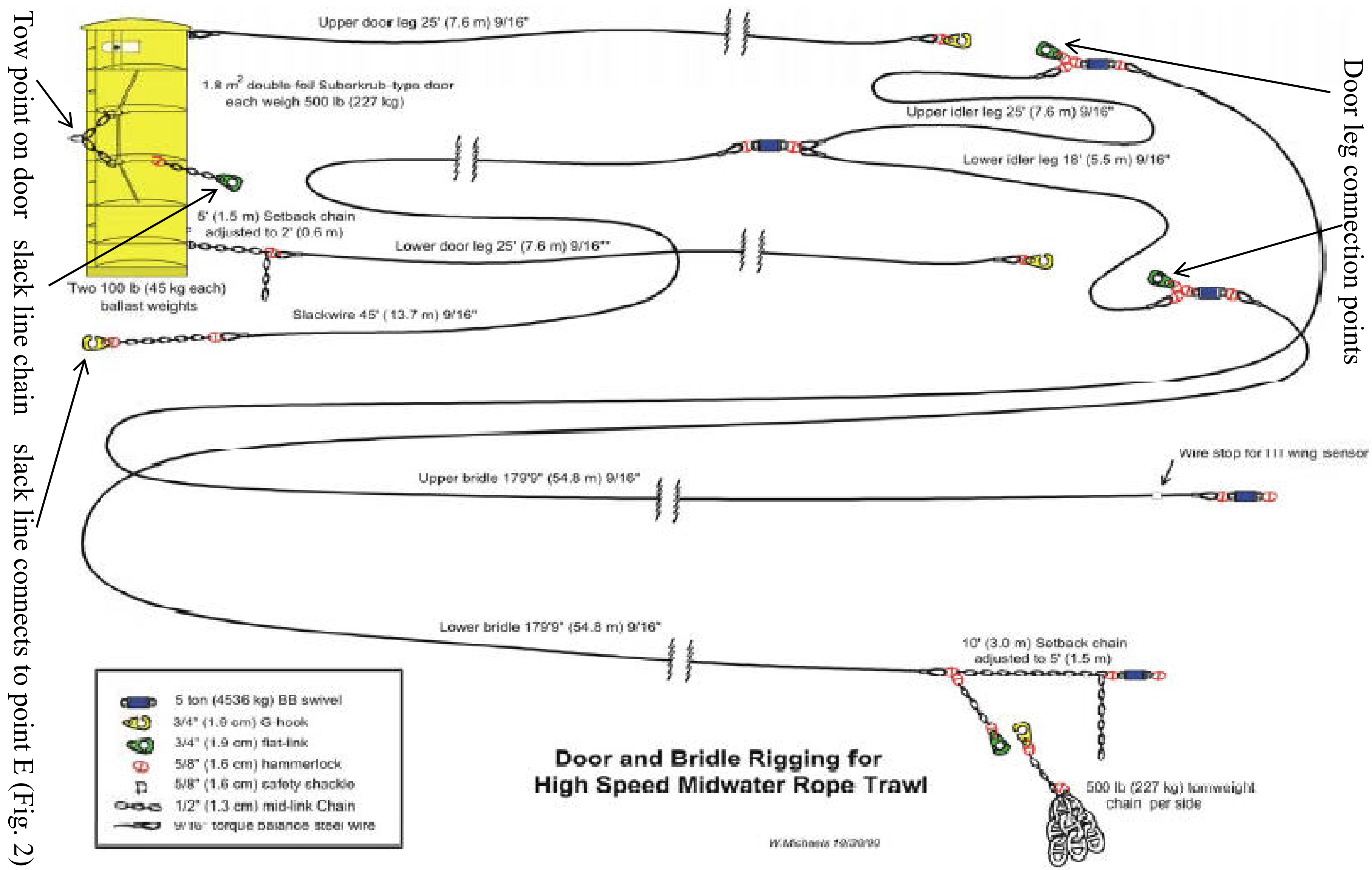


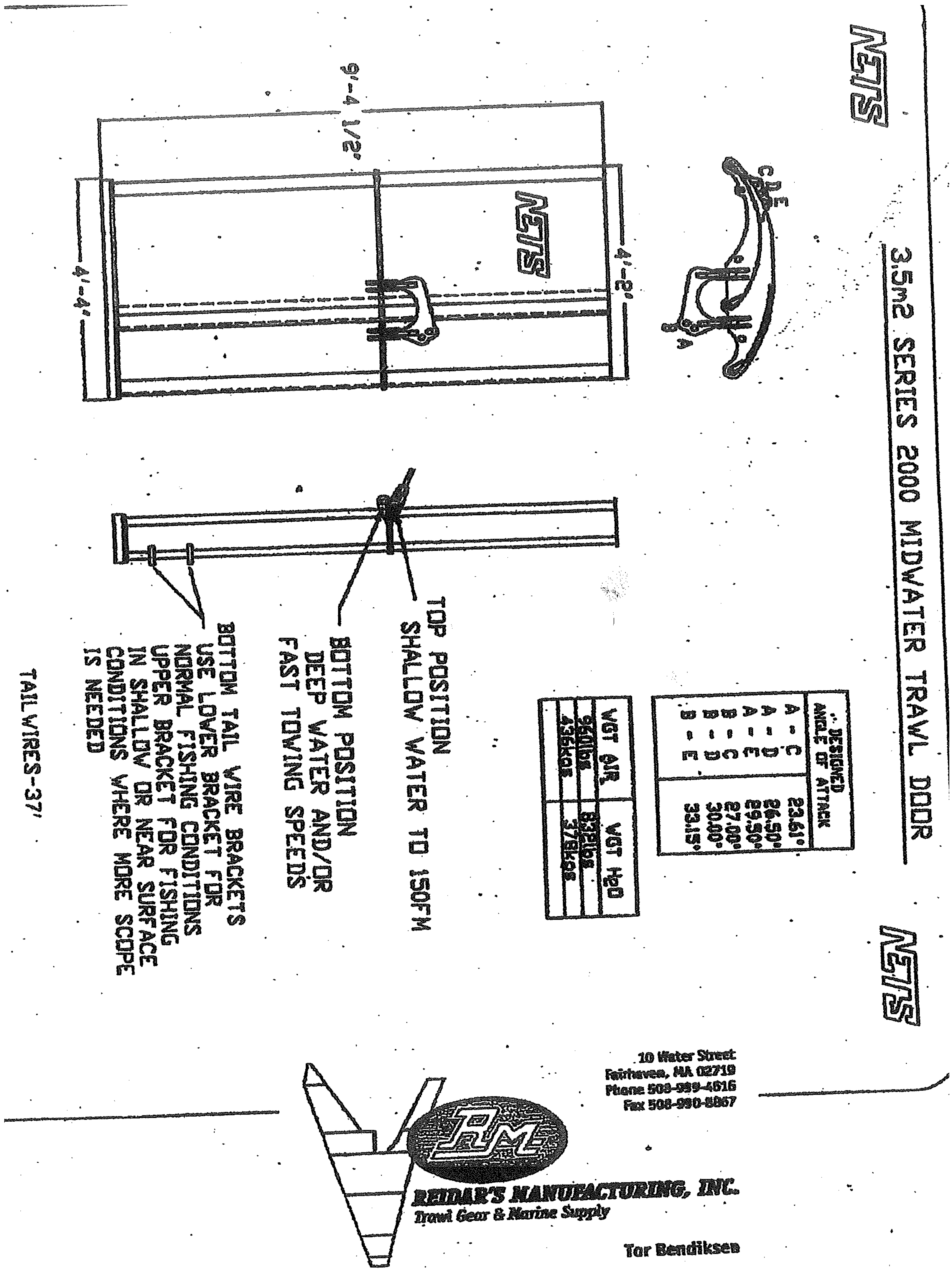
Figure 4

NOTE: The lengths in this diagram are correct, but we now use 1"-diameter spectra for all the rigging. The tomweight weight is about 700 lbs.



****This is a generic schematic. The lengths and weights on this are not necessarily accurate, but the configuration is representative of the net rigging used for the midwater trawl on the R/V Armstrong**

Figure 5


3.5m2 SERIES 2000 MIDWATER TRAWL DOOR
NETS
DESIGNED ANGLE OF ATTACK
A - C 23.61°
A - D 26.50°
A - E 29.50°
B - C 27.00°
B - D 30.00°
B - E 33.15°
WGT AIR 960lbs 436kgs
WGT H2O 832lbs 378kgs
4'-2"
9'-4 1/2"
4'-4"
TOP POSITION
SHALLOW WATER TO 150FM
BOTTOM POSITION
DEEP WATER AND/OR
FAST TOWING SPEEDS
BOTTOM TAIL WIRE BRACKETS
USE LOWER BRACKET FOR
NORMAL FISHING CONDITIONS
UPPER BRACKET FOR FISHING
IN SHALLOW OR NEAR SURFACE
CONDITIONS WHERE MORE SCOPE
IS NEEDED
TAILWIRES-37'
10 Water Street
Fairhaven, MA 02719
Phone 508-999-4616
Fax 508-990-8867
REIDAR'S MANUFACTURING, INC.
Trawl Gear & Marine Supply
Tor Bendiksen

Setup of Midwater Trawl and Bridles

1. The midwater net is towed by the 0.68 conductor wire on the R/V Armstrong, so a "single warp" and bridle system was developed to set and retrieve the net.
2. From the doors to the net, the setup is nearly identical to all other midwater trawl configurations, with the exception of adding one hammer lock and flat link to the tow point (Figs. 1, 2, & 4). This extra flat link is used to take the tension off the tow line so that the bridle can be used to reel the net up on the drum.
3. The bridle configuration is shown in Figure 2, and the drum idler is shown in Figure 3.
4. The net rigging is shown in Figure 4.
5. To set up the rigging:
    a. Connect the drum idlers to the net drum with a shackle (Fig. 3).
    b. Spool the drum idlers onto the net drum.
    c. On the long bridle section (sections C-E, Fig. 2), tape the g-hook at point C back on to the bridle with a couple of wraps of electrical tape. Use point D as the bend point because you will connect the drum idler to the flat link at point D. In other words, take the 6-ft section and lay it back on the bridle and tape the g-hook to the bridle.
    d. Connect the end of each drum idler (point H, Fig. 3) to its corresponding bridle at point D (Fig. 2)
    e. Spool the bridles onto the net drum until point E (Fig. 2).
    f. Connect the slack line on the net rigging (Fig 4.) to the bridles at point E.
    g. Spool the net rigging onto the net drum. Maintain as much tension as you can!
    h. Spool as much of the net as possible onto the drum.
6. Connect the door legs to the doors. Usually, the color code is red for upper, and green for lower (think of a stop light).
7. Secure the doors with the stopper chains and the stopper chains to the deck. You will need to figure out the best length of chain to use and the location of the stopper chain on the deck when you are at the dock.
8. Connect the top part of the tow bridle to the termination block (Section A, Fig. 2) on the .68 tow wire.
    a. Optional. We connected two "lazy lines" to the shackle at the termination block. These were about 25 ft in length and just hung from the shackle. We did not use them, but the idea was that if the angle of the tow wire was such that we couldn't reach the connection points from the deck, we could use them to keep the connection point (Points A & B, Fig. 2) within reach.
9. To deploy the net, the drum idlers are connected to the tow bridles, which are connected to the slack lines of the net rigging.
10. We generally use ~150 lb tom weights for the small Swan net, but we did not use them on the Armstrong. They are optional.
11. All connections that need to be connected or disconnected during deployment and retrieval are done with flat links and g-hooks.

Midwater Trawl Setup (continued)

12. The lengths of the forward bridle sections (points A-B and C-D) are set for the gantry height of the R/V Armstrong, which is about 30 ft. If the gantry of the vessel is shorter, you may need to shorten these lengths. These lengths should be sufficient for taller gantries.
13. Midwater trawl doors have multiple attachment points to make the “angle of attack” more aggressive (i.e., spread more) or more conservative (i.e., spread less). Figure 5 shows the attachment points for a set of midwater trawl doors (we did not use these specific doors, but they are used as an example). For the R/V Armstrong we chose to use the most aggressive set because of the limited bridle length. We didn’t have mensuration, but when the doors were coming up, they were spread about the width of the boat, which is about 50 ft, so I think the spread was about 15 m. When we fished our larger midwater net, the horizontal mouth opening was about 30 m, and the door spread was about 75 m, which is a factor of about 2.5. Applying that to the small net, for a door spread of about 15 m, that should give a horizontal mouth opening of about 6 m, which is close to what we measure on the Bigelow (we actually get closer to 8 m horizontal opening, so we could use longer bridles).

Deploy Midwater Trawl

1. To deploy the net, the slack line of the net rigging should be connected to the bridles, which are connect to the drum idlers, and they are spooled onto the drum. Spool as much of the net on the drum as possible. (see #5 in "Setup of Midwater Trawl") This will give you a controlled set.
2. Inform the bridge that you want to fish!
3. Setting the net takes about 1 nautical mile (nmi), so the bridge command should decide on a direction and then steam 1 nmi to set up for the trawl.
4. Flake the net out on deck, with as much as possible towards the stern. Make sure the slack line is connected to the drum idler! (otherwise, you'll lose your net)
5. Make sure the doors are secured to the deck with the stopper chains.
6. If you are attaching temperature-depth recorders (TDRs), attach them before you set the net.
7. When ready to set the net, the vessel speed should be about 1-1.5 kt.
8. When the bridge and deck crew are ready, throw the codend over the transom and continue to feed the net into the water. This may take several people, especially when you get to the wings and footrope.
9. The net will trail behind the vessel and then the rigging will continue off the net drum. Make sure the net drum operator keeps pace with the net as it trails back.
10. If possible, keep the upper bridle leg from twisting on the lower bridle leg. You can do this by keeping your hands on the upper leg as it passes aft. Don't "hold" the line – let it slip through your hands.
11. When the connection points for the door legs (Fig. 4) reach the doors, have the net drum operator stop paying out line.
12. Connect the appropriate door leg to the appropriate connection on the rigging. Do not cross the legs!! The color code should be red for upper and green for lower (think of a stop light). If you pull up on the upper leg, you should be able to see how the lower leg gets connected. Most of the time, you need to go under the upper leg.
13. Once both door legs are connected, have the drum operator slowly let out line. At this point, the tension will transfer from the net drum (via the drum idlers) to the doors. Make sure the doors are secure!
14. After all the tension is on the doors, the slack lines will become slack (hence the name). Disconnect the slack line from the drum idler and connect it to the door via the "slack line" connection (Figs. 1 & 4, "for slack line").
15. Connect the ends of the tow bridles to the appropriate doors via the flat links furthest from the door at the tow point (point E to point F, Fig. 2).
16. Have the drum operator spool <u>IN</u> on the bridle. This will transfer the tension from the stopper chains and doors to the bridle.
17. Disconnect the stopper chains from the doors.
18. Have the drum operator slowly pay out on the bridle until all the tension is on the bridles. After this, the drum operator can pay out as fast as he/she can.
19. When the bridles are out (point D, Fig. 2) and near the transom, have the net drum operator stop paying out.

Deploy Midwater Trawl (continued)

19. Now you must transfer tension from the net drum to the tow wire.
    a. Take the g-hook that was taped to the bridle (point C) and break the tape.
    b. Connect the g-hook to the top bridle section at point B (point B to point C).
    c. Have the net drum operator pay out until the tension is off the drum idlers and on to the tow wire.
    d. Disconnect the drum idler (point D).
20. All tension should be on the tow wire now.
21. Bring the vessel speed up to 2.5 kts or so, and have the tow winch operator pay out to the designated amount of wire out.
22. Fish!
23. While the net is fishing, pull the drum idlers through the Gifford blocks so that the ends of the idlers (point H, Fig. 3) are on the deck. You will need these when retrieving the net.

Retrieve Midwater Trawl

1. Retrieving the trawl is almost the reverse of setting it out, with the exception of using the Gifford blocks to raise the doors to the deck.
2. Make sure you have the drum idlers through the appropriate Gifford blocks.
3. Inform the bridge that you are retrieving the net.
4. Ask the winch operator to haul back on the tow wire. Haul back on the tow wire until the termination block is near the big ".68 conductor block" (Fig. 1).
5. Have the ship slow speed to about 1-1.5 kts. If needed, you can use the lazy lines to so that you can reach the first connection point (point B, Fig. 2). You can slow the vessel down more if needed to get to the connection point, and you can have the gantry angled forward.
6. Connect the drum idlers (point H, Fig. 3) to the tow bridles at point D (Fig. 2). Use the flat link furthest aft.
7. Have the net drum operator haul the drum idlers in. When the tension is transferred to the drum idlers, have the net drum operator stop.
8. Ask the winch operator to slack on the tow wire until you can reach points B-C.
9. Disconnect the bridle from the tow wire and tape the g-hook (point C) back onto the bridle (as in step 5.c. in "Midwater trawl set up"). You need to do this otherwise this loose section can get caught in the block or in the net drum.
10. If you angled the gantry forward, you may need to have it angled aft so the doors don't hit the transom.
11. Have the net drum operator haul the idlers and bridles in until the door height is above the deck. Check that the bridles are on spooling onto the drum. There will be a steep angle from the blocks to the net drum.
12. Angle the gantry forward and have the net drum operator pay out or in so the doors are above and over the deck. This is the trickiest part of the process. The doors will be swinging freely, so it is really important to be extremely cautious and safe.
13. Lower the doors so that you can attach a stopper chain to each door. Use the flat link that is closest to the door. When the stopper chain is attached, have the net drum operator pay out so that all the tension is on the doors and stopper chain, and the bridles are slack.
14. Disconnect the tow bridles (point E, Fig. 2) from the tow point of the doors.
15. Attach a line to point E (Fig. 2) and pull the bridles out through the Gifford blocks. You are done with these blocks and now the haul will be done with the bridles and rigging running along the deck. MAKE SURE YOU ATTACH A LINE!! OTHERWISE YOU WON'T HAVE ANYWAY TO GET THE IDLERS BACK THROUGH THE BLOCKS FOR THE NEXT NET SET!!
16. At this point, all the tension is on the doors and door legs. The slack line will be slack.
17. Disconnect the slack line (Fig. 4) from the door and attach each to the corresponding bridle (point E, Fig. 2).

Retrieve Midwater Trawl (continued)

18. Have the net drum operator begin to haul in at a medium speed. If necessary, have 1-2 people on each side acting as "human level winds". It's important to have the bridles and rigging spread out over each side of the drum so that the lines don't bunch up and fall over on themselves, which can cause a problem when setting out the next time. We use spectra, so it's safe and easy to handle.
19. When the door leg connection points (Fig. 4) come safely onto the deck,, have the net drum operator stop before disconnecting each door leg.
20. After both door legs are disconnected, continue to spool in. Again, you may need "human level winds".
21. Continue to bring the net on board. If you attached TDRs, make sure you get them off before the net gets wrapped up on the drum!!
22. Once the codend is on board (or however much of the net can fit on the drum), have the net drum operator stop. You may need to bring the codend up by hand.
23. Open the codend and see what you caught!